SINGAPORE SPORT & PERFORMANCE CONFERENCE 2022

From Youth to Elite Sport: Harnessing Potential and the Pursuit of Excellence

2nd - 4th November 2022

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SINGAPORE SPORT & PERFORMANCE CONFERENCE 2022

From Youth to Elite Sport: Harnessing Potential and the Pursuit of Excellence

Climate Change: Managing the Health and Performance Impacts of Air Pollution and Heat on Exercise and Training

Michael Koehle, MD PhD

Professor, School of Kinesiology

Director, Division of Sport & Exercise Medicine

UBC Environmental Physiology Laboratory

Disclosures

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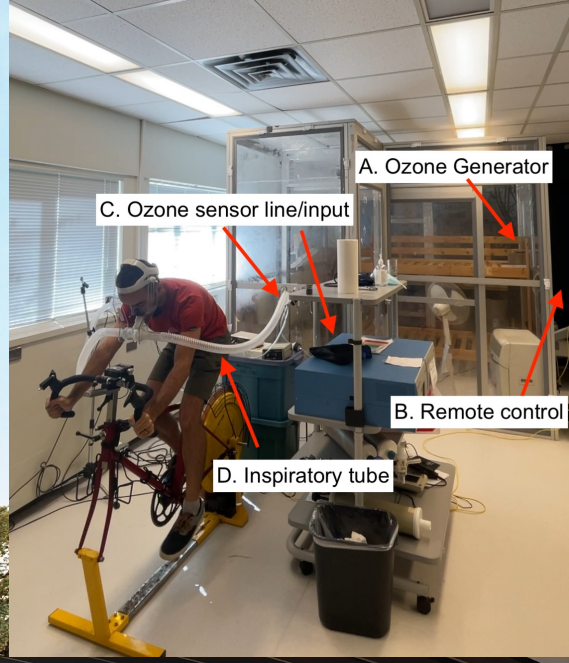

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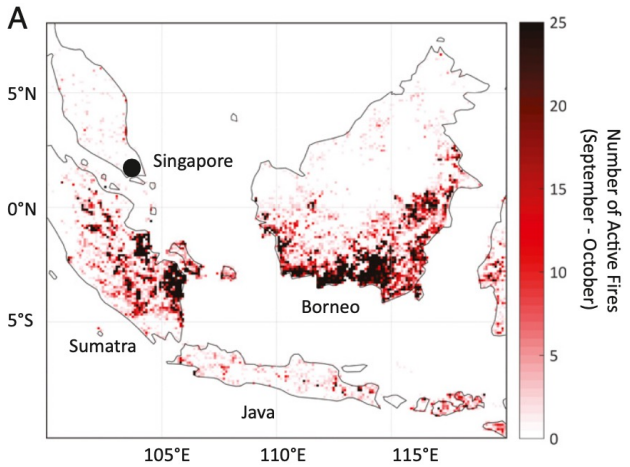
AIR POLLUTION

Why is Air Pollution Relevant to Climate Change?

- Air Pollution ≠ Greenhouse Gases

  - More frequent heat waves – ground level ozone
  - Wildfire frequency and severity – Particulate Matter



Singapore Haze

- Burning of Indonesian peat
- Deforestation fires
- Agricultural waste burning

SINGAPORE SP
PERFORMANCE CO
From Youth to Elite Sport: Harnessi

May 2018

October 2022

Case 1

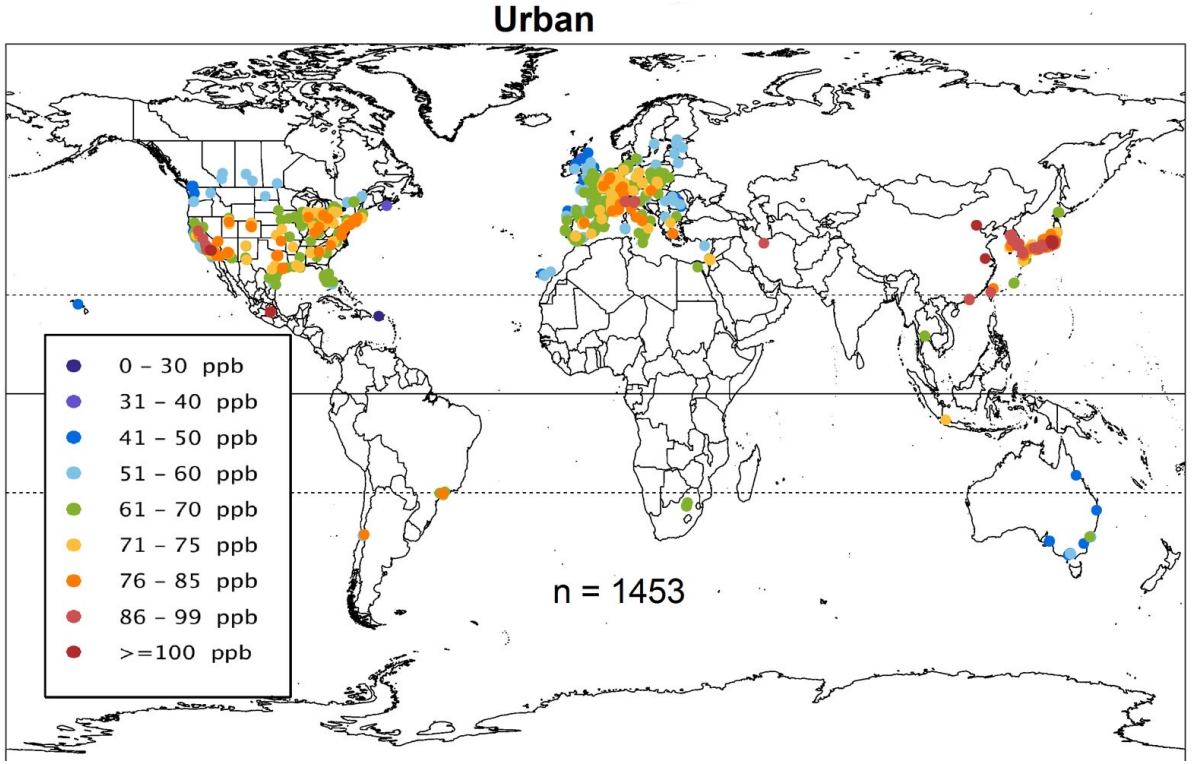
IAAF World Athletics Championships
DOHA2019™
بطولة العالم لألعاب القوى - الدوحة

- …there has been some concern about the air quality and it's potential health impact on the athletes…
- …this morning at 9am was 112ug/m3 and that is rated "Unhealthy for Sensitive Groups". The forecast is for the AQI to move to "Unhealthy" tomorrow and to hover there for most of next week…
- …the marathon and race walk events …are all occurring at night with start times either 11:30pm or 12am …
- …some staff are concerned that we are placing our athletes at serious health risk by allowing them to compete in these events…

Case 2

Tokyo Olympic Games

- Temperatures >30 C (mean 32.2C) with humidity ~70%
- Generally lower levels of particulate matter especially at night
- Highest ozone levels in the OECD – Games held during peak ozone season



The Problem with Intense Exercise

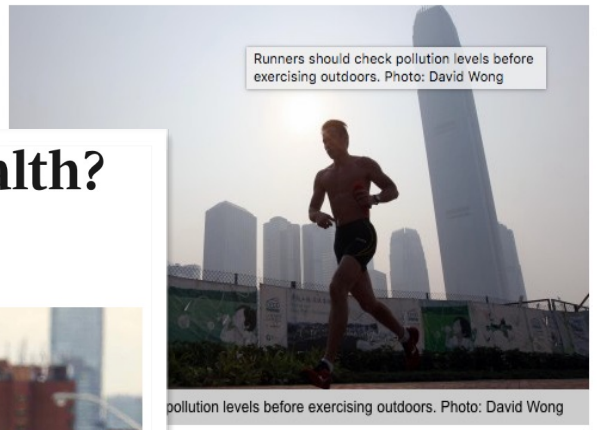
LIFESTYLE • HEALTH

Exercising when air pollution levels are high can do more harm than good

Exercising when air pollution levels are high can end up doing more harm than good, writes Rachel Jacqueline

Rachel Jacqueline
life@scmp.com

PUBLISHED : Tuesday, 01 July, 2014, 9:41am
UPDATED : Tuesday, 01 July, 2014, 9:41am


Runners should check pollution levels before exercising outdoors. Photo: David Wong

pollution levels before exercising outdoors. Photo: David Wong

SHARE

Email Print

Dirty air affecting your health? Pedal harder

A cyclist pedals along in traffic on Danforth Ave. near Woodbine in Toronto on Oct. 21, 2013. A study presented at the annual conference of the Canadian Society for Exercise Physiology in Toronto in October suggested an increase of exercising benefits when pushing harder and breathing polluted air more deeply.

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Exercise and Inhaled Pollution

Exercise

Air Pollution Inhalation

↑ Minute Ventilation

Nasal → Oral Breathing

↑ Effects of Air Pollution?

↑ Deposition in the Lungs

↑ Pulmonary Diffusion Capacity

Giles, LV, & Koehle, MS. Sports Med. 2014;44(2):223-249.

Air Pollution Recipe

- Gases
  - Ozone, carbon monoxide, oxides of nitrogen (NO_2, NO), etc.

- Particles
  - Solid particles, or liquid droplets like dust, metal, black carbon, pollen

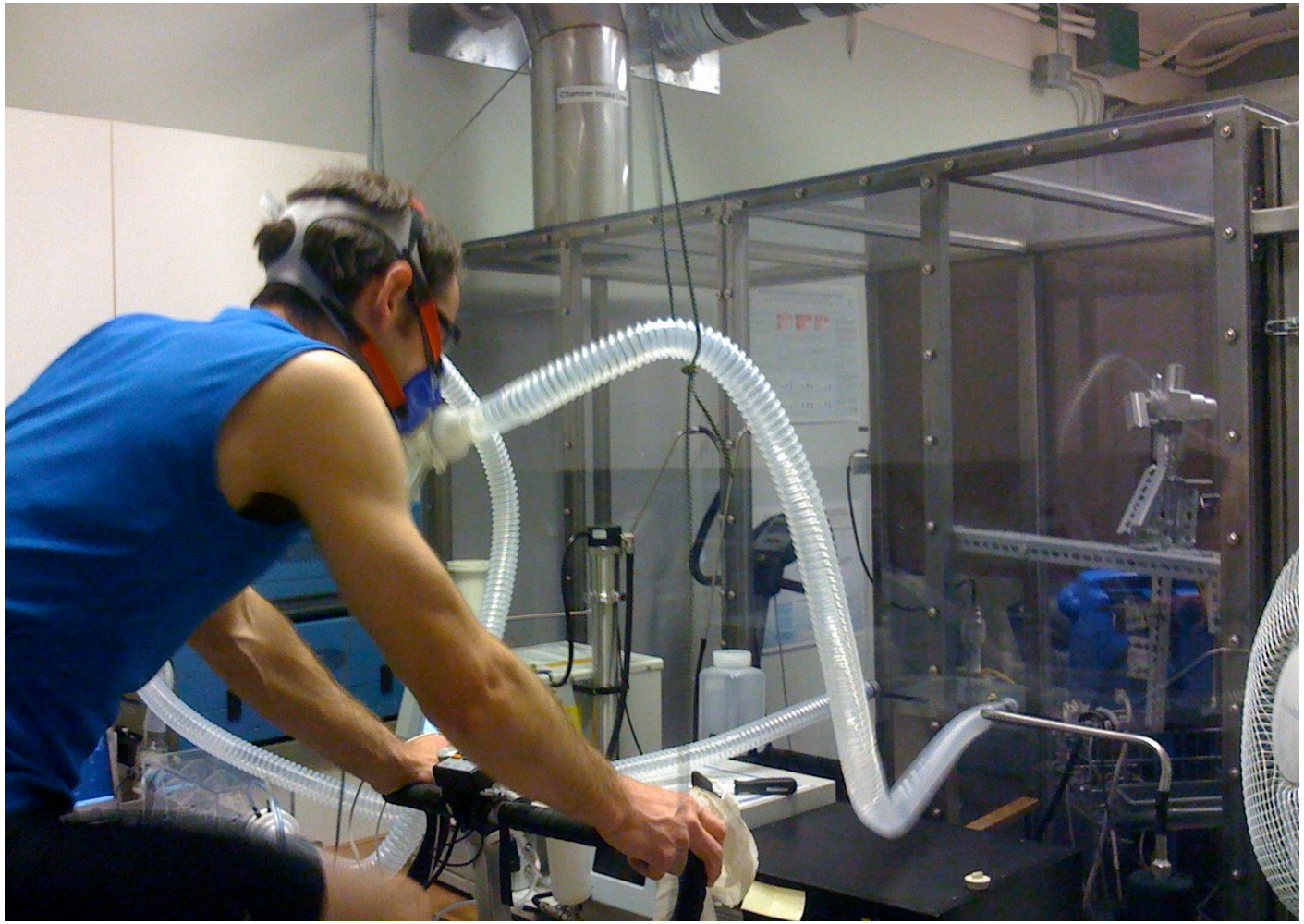
Research Models

- **Real World Acute Exposures**
  - Realistic pollution exposures
  - Tough to generate control exposures, with blinding
  - Good Pollution Recipe

Images: Andy Hung MSc

Research Models

- **Laboratory Acute Exposures**
  - Controlled consistent pollution exposure
  - Sham condition, blinding crossover design
  - Lack of long-term results
  - Approximate Recipe



Research Models

- **Real World Epidemiology Studies**
  - Long-term results -
  - Large sample sizes
  - Control groups and blinding lacking
  - Confounders
  - Good Pollution Recipe

Health Effects of Air Pollution

- 4.2 Million deaths/year – predominantly LMIC

- Cardiovascular
  - Ischaemic heart disease and stroke
- Respiratory
  - Chronic Obstructive Pulmonary Disease And Lower Respiratory tract Infections (18%)
  - Lung Cancer (6%)
- Diabetes
  - Increased incidence of Type 2 Diabetes Mellitus with $PM_{2.5}$ exposure ~10%
- Cognitive
  - Associated with decreased cognitive function and dementia

A Section 508–conformant HTML version of this article
is available at http://dx.doi.org/10.1289/ehp.1408698.

Resear

A Study of the Combined Effects of Physical Activity and Air Pollution on Mortality in Elderly Urban Residents: The Danish Diet, Cancer, and Health Cohort

Zorana Jovanovic Andersen,[1,2] Audrey de Nazelle,[3] Michelle Ann Mendez,[4] Judith Garcia-Aymerich,[5,6,7] Ole Hertel,[8] Anne Tjønneland,[2] Kim Overvad,[9,10] Ole Raaschou-Nielsen,[2] and Mark J. Nieuwenhuijsen[5,6,7]

[1]Center for Epidemiology and Screening, Department of Public Health, University of Copenhagen, Copenhagen, Denmark; [2]Danish Cancer Research Center, Danish Cancer Society, Copenhagen, Denmark; [3]Centre for Environmental Policy, Imperial College London, London, United Kingdom; [4]Department of Nutrition, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA; [5]Center for Research in Environmental Epidemiology (CREAL), Barcelona, Spain; [6]Universitat Pompeu Fabra, Barcelona, Spain; [7]CIBI Epidemiología y Salud Pública (CIBERESP), Barcelona, Spain; [8]Department of Environmental Science, Aarhus University, Roskilde, Denmark; [9]Section for Epidemiology, Department of Public Health, Aarhus University, Aarhus, Denmark; [10]Department of Cardiology Aalborg University Hospital, Aalborg, Denmark

BACKGROUND: Physical activity reduces, whereas exposure to air pollution increases, the risk of premature mortality. Physical activity amplifies respiratory uptake and deposition of air pollutants in the lung, which may augment acute harmful effects of air pollution during exercise.

2008), cycling during rush hour on a h
traffic route (Strak et al. 2010), or hikin
high air pollution days (Korrick et al. 1
Similarly, exposure to air pollution

Diabetologia (2021) 64:1298–1308
https://doi.org/10.1007/s00125-021-05408-4

ARTICLE

Habitual exercise is associated with reduced risk of diabetes regardless of air pollution: a longitudinal cohort study

Cui Guo[1] · Hsiao Ting Yang[2] · Ly-yun Chang[3] · Yacong Bo[1,4] · Changqing Lin[5,6] · Yiqian Zeng[1] · Tony Tam[7] · Alexis K. H. Lau[5,6] · Gerard Hoek[2] · Xiang Qian Lao[1,8]

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IEA International Epidemiological Association

International Journal of Epidemiology, 2019, 1–11
doi: 10.1093/ije/dyz184
Original article

Original article

Benefits of physical activity not affected by air pollution: a prospective cohort study

Shengzhi Sun ,[1,2†] Wangnan Cao,[3†] Hong Qiu,[1] Jinjun Ran,[1] Hualiang Lin,[4] Chen Shen,[5] Ruby Siu-Yin Lee[6] and Linwei Tian[1*]

Association of Physical Activity with Incidence of Dementia Is Attenuated by Air Pollution

DAVID A. RAICHLEN[1], MELISSA FURLONG[2], YANN C. KLIMENTIDIS[3,4], M. KATHERINE SAYRE[1], KIMBERLY L. PARRA[3], PRADYUMNA K. BHARADWAJ[5,6], RAND R. WILCOX[7], and GENE E. ALEXANDER[4,5,6,8,9,10,11]

[1]Human and Evolutionary Biology Section, Department of Biological Sciences, University of Southern California, CA; [2]Department of Community, Environment, and Policy, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ; [3]Department of Epidemiology and Biostatistics, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ; [4]BIO5 Institute, University of Arizona, Tucson, AZ; [5]Department of Psychology, University of Arizona, Tucson, AZ; [6]Evelyn F. McKnight Brain Institute, University of Arizona, Tucson, AZ; [7]Department of Psychology, University of Southern California, CA; [8]Department of Psychiatry, University of Arizona, Tucson, AZ; [9]Neuroscience Graduate Interdisciplinary Program, University of Arizona, Tucson, AZ; [10]Physiological Sciences Graduate Interdisciplinary Program, University of Arizona, Tucson AZ; and [11]Arizona Alzheimer's Consortium, Phoenix, AZ

Chronic Health Effects Summary

- AIR POLLUTION = BAD
- EXERCISE = GOOD

Sports Medicine
https://doi.org/10.1007/s40279-021-01544-4

SYSTEMATIC REVIEW

The Acute Effects of Exercising in Air Pollution: A Systematic Review of Randomized Controlled Trials

Andy Hung[1] · Hannah Nelson[1] · Michael S. Koehle[1,2]

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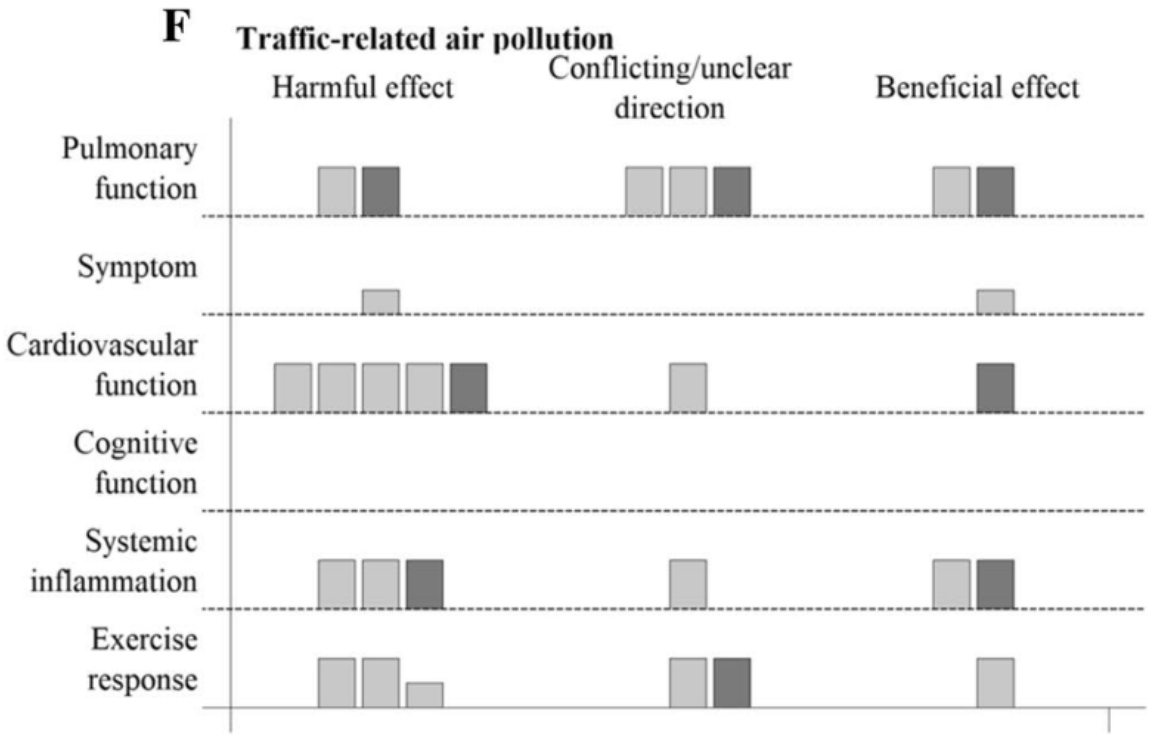
Sports Medicine
https://doi.org/10.1007/s40279-021-01544-4

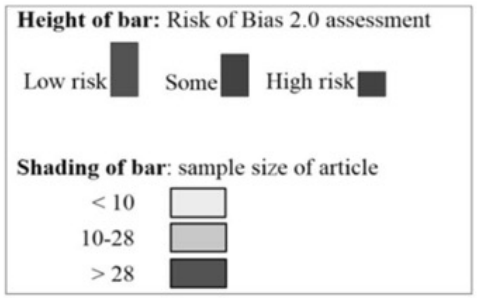
SYSTEMATIC REVIEW

The Acute Effects of Exercising in Air Pollution: A Systematic Review of Randomized Controlled Trials

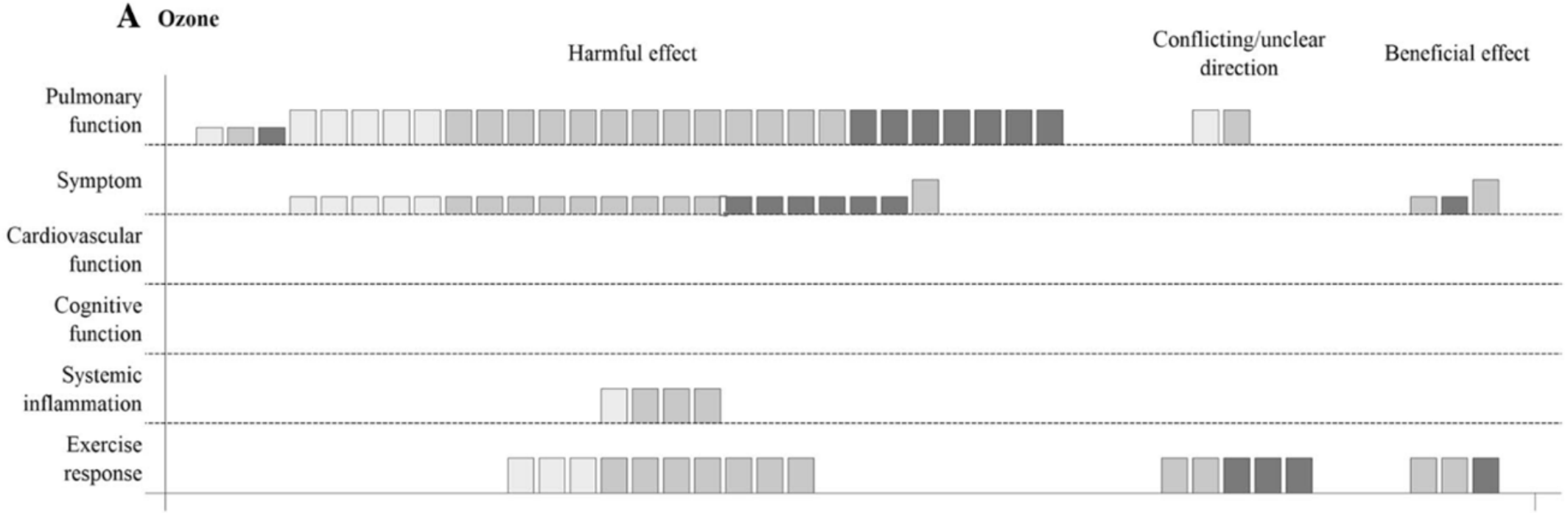
Andy Hung[1] · Hannah Nelson[1] · Michael S. Koehle[1,2]

- Traffic-related air pollution
  - High in particulates
  - Acute **Health** effects of exercise are somewhat equivocal
  - **Performance** Effects are equivocal

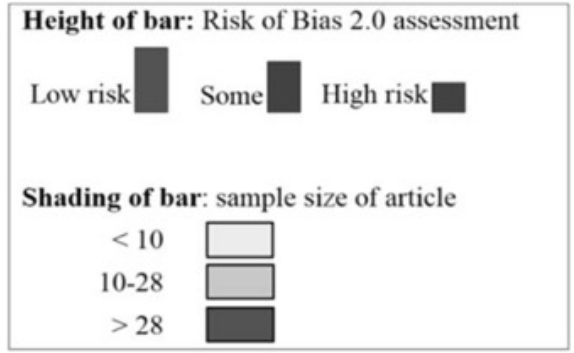




Ozone Effects



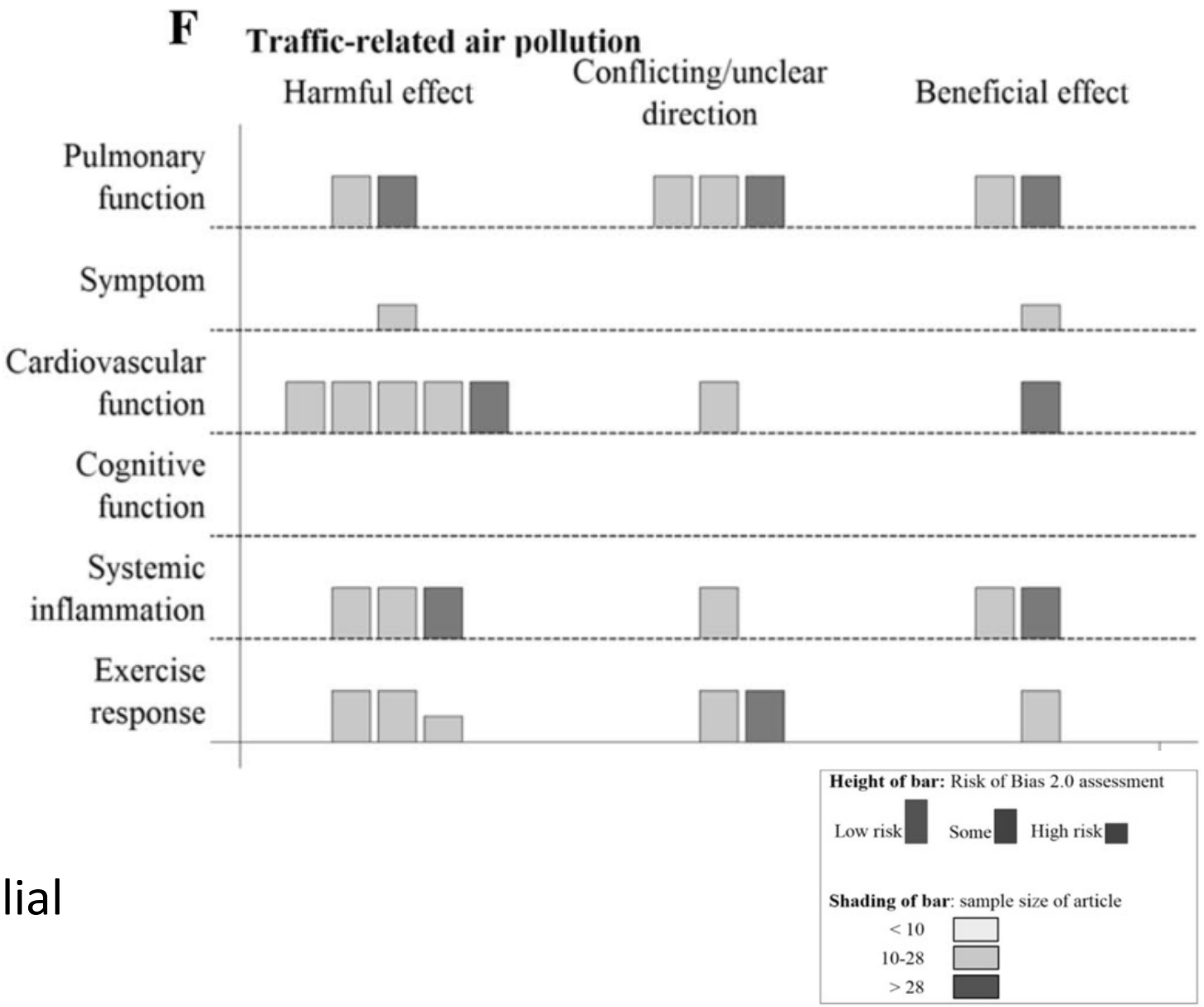
- Consistent worsening of lung function (FVC, FEV1, FEF25-75)
- Consistently increases symptoms
  - Cough and dyspnoea
  - When O_3 levels higher than ~120ppb
- Increased inflammatory markers (IL-6, neutrophils)



Traffic-related Air pollution - TRAP

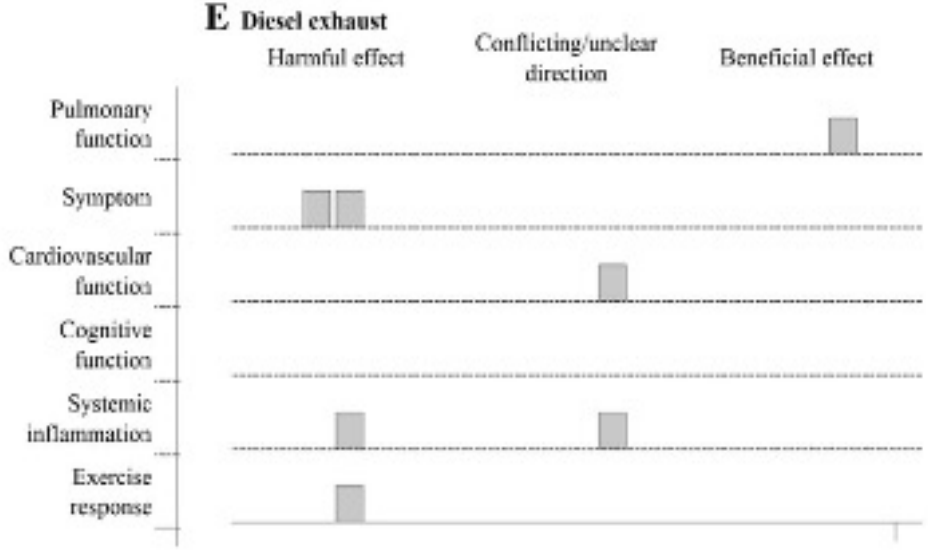
- Inconsistent effect on:
  - Lung function
  - Exercise response
  - Symptoms
  - Inflammatory responses

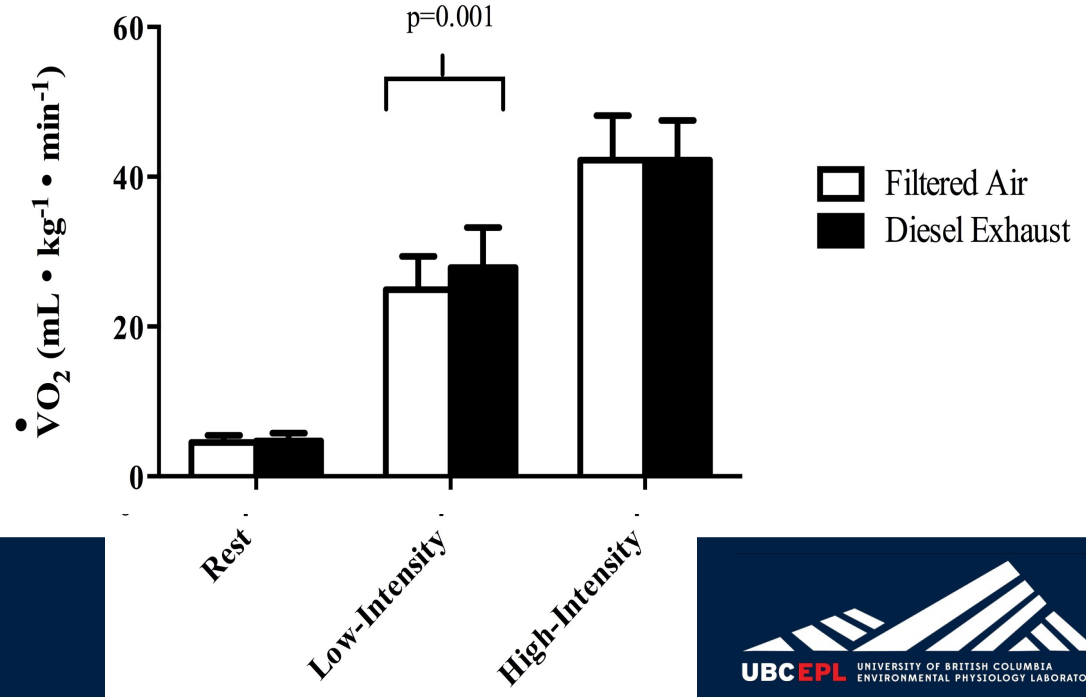
- Cardiovascular responses
  - Likely increase in blood pressure
  - Heart rate variability and endothelial function unclear



Diesel Exhaust (DE) Effects

- No effect on lung function or heart rate variability
- Inconsistent effect on symptoms
  - Small effect in one study
- No real effect of exercise intensity



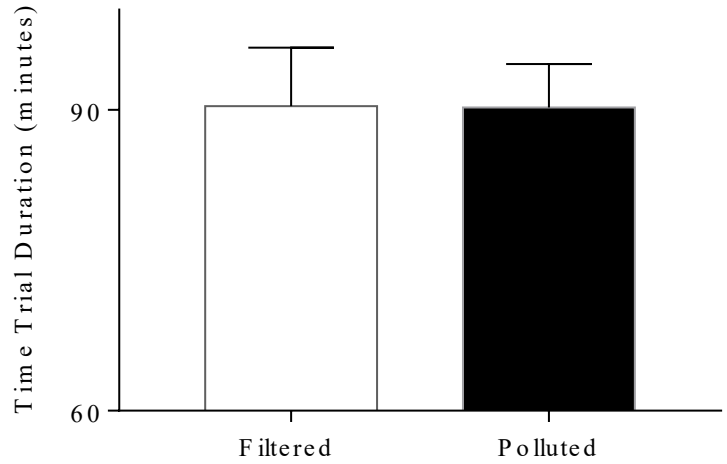


Acute Health Effects Summary

- Ozone
  - Decreased lung function compared to filtered air
  - Increased symptoms compared to filtered air

- TRAP and Diesel Exhaust
  - Inconsistent acute health effects

Performance Effects - TRAP

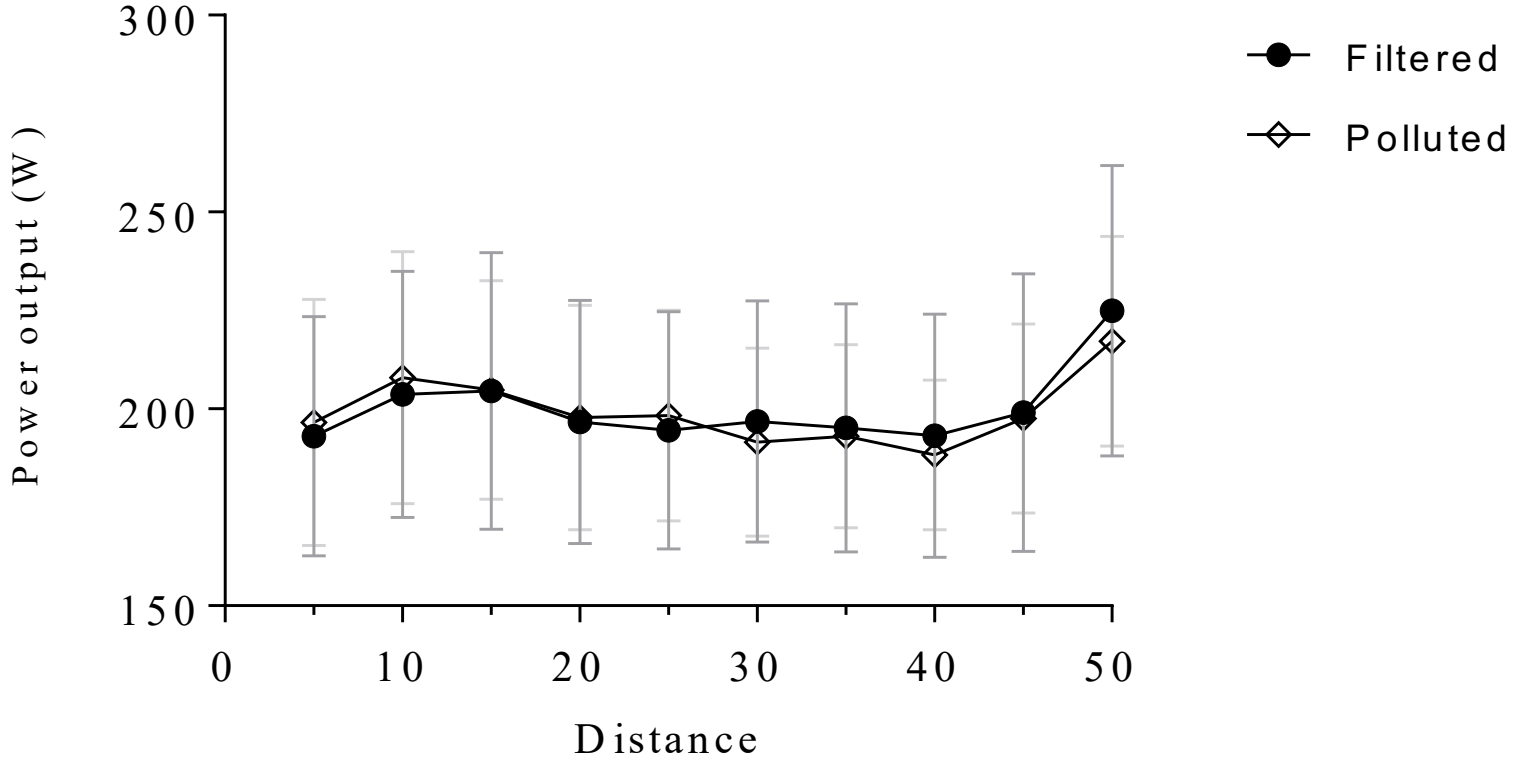


Research Article

Effects of air pollution exposure on inflammatory and endurance performance in recreationally trained cyclists adapted to traffic-related air pollution

André Casanova Silveira*, Julio Satoshi Hasegawa, Ramon Cruz, Monique Matsuda, ... See all authors

12 APR 2022 // https://doi.org/10.1152/ajpregu.00305.2021



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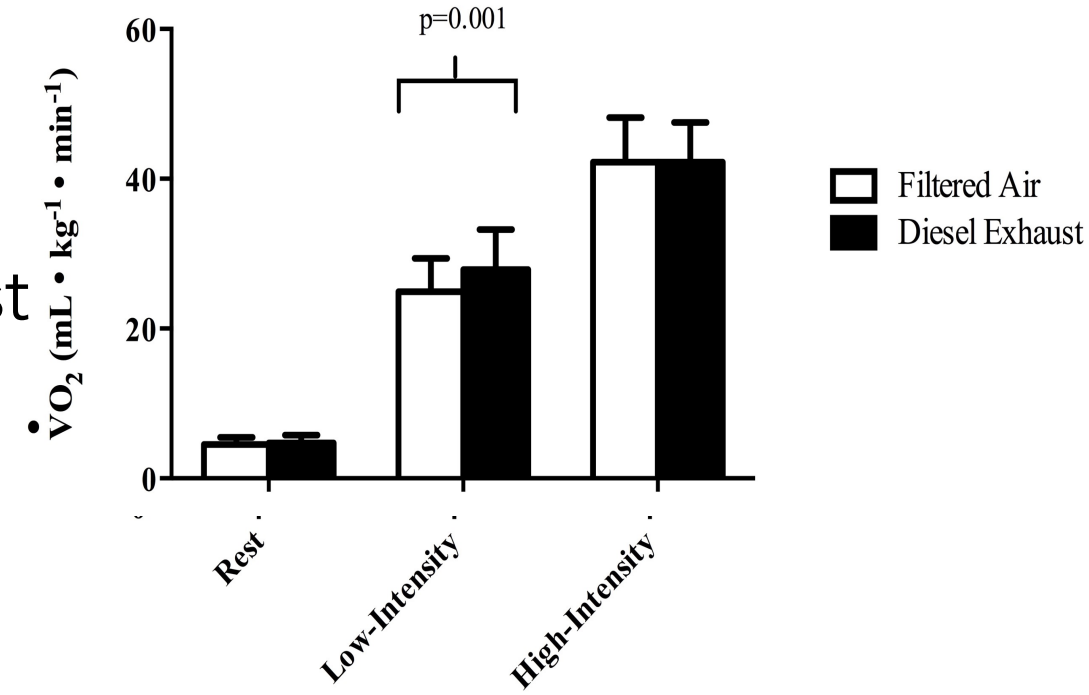
Performance Effects - Diesel

- Diesel Exhaust Exposure study
- Healthy males 30 min cycling
- Increased perceived effort
- At low intensity, increased oxygen cost



Giles et al. 2012, Giles et al. 2016

Ozone and Performance

DECREASED VO2MAX DURING EXERCISE

DECREASED RUNNING PERFORMANCE

SYMPTOMS INCREASED

ADAPTATION?

Ozone and Adaptation

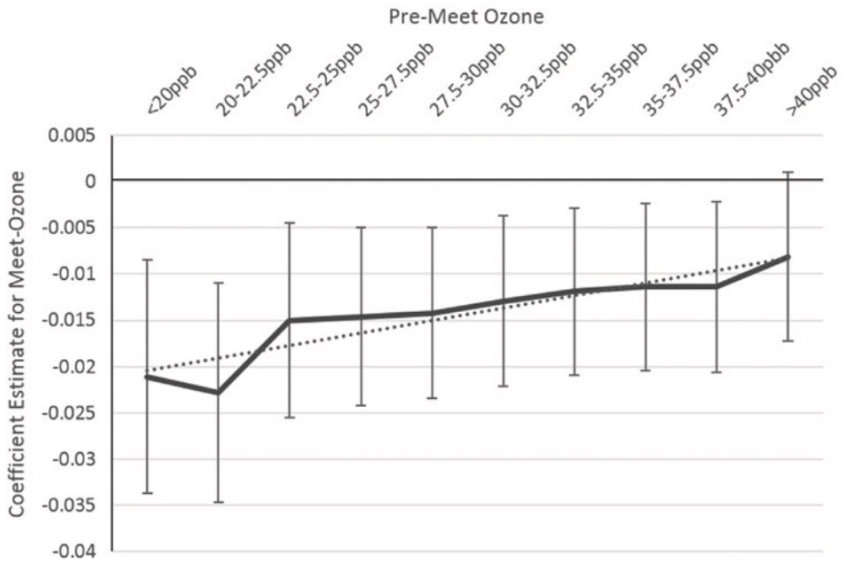
Health Economics

RESEARCH ARTICLE

Ambient air pollution and human performance: Contemporaneous and acclimatization effects of ozone exposure on athletic performance

Jamie T. Mullins

Fir



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Effects of ozone exposure on four consecutive days on work performance and $\dot{V}O_{2\,max}$

WILLIAM J. FOXCROFT AND WILLIAM C. ADAMS
Human Performance Laboratory, Department of Physical Education, University of California, Davis, California 95616

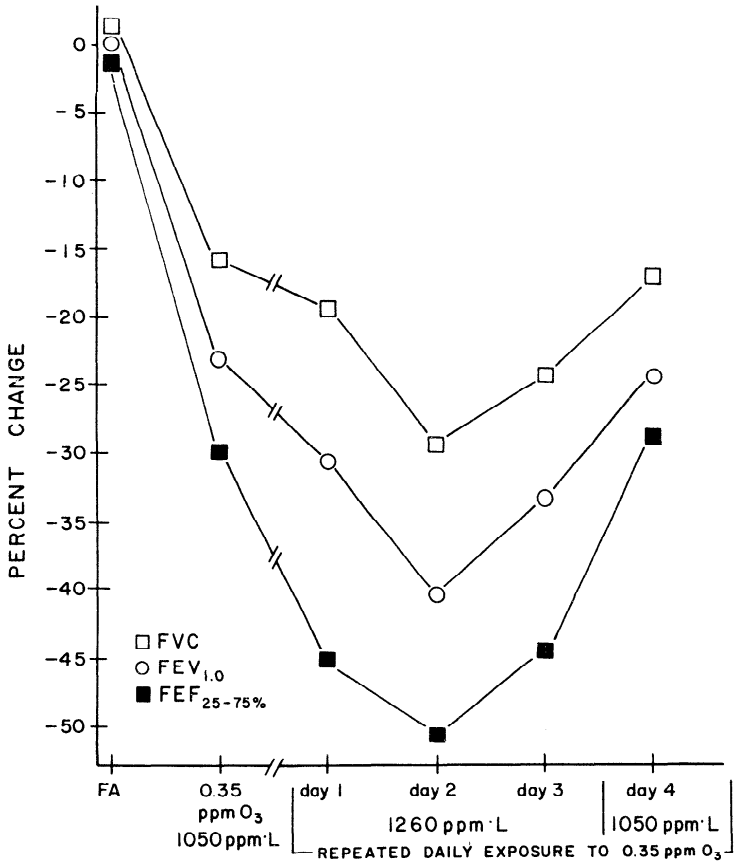
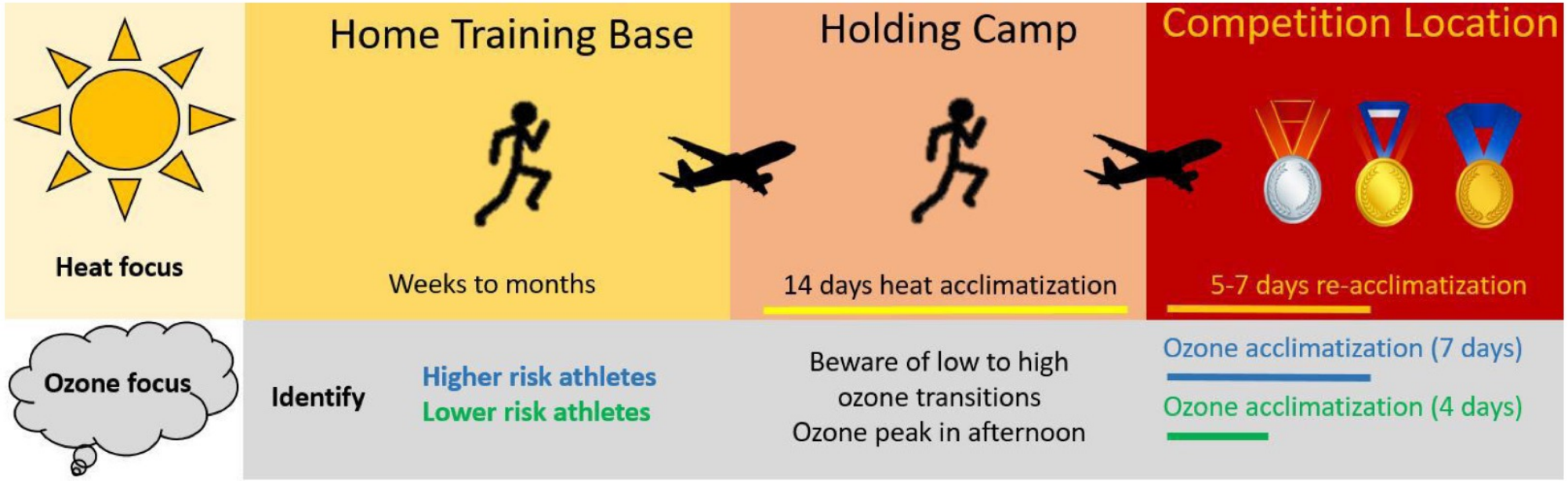


FIG. 3. Percent change in pulmonary function on initial exposure and as a result of 4 consecutive days exposure to 0.35 ppm O_3. See text for definitions and additional details.

Ozone and Heat



Athlete performance checklist	Athlete health checklist
➢ Heat/humidity gauge ☐	➢ Medication ☐
➢ Cloud cover forecast ☐	➢ Individual symptom time course ☐
➢ Acclimatization plan ☐	➢ Travel/Jet lag ☐

Figure 1 Summary of how to concurrently prepare to compete in the heat with high levels of ozone. An athlete performance and health checklist for science and medicine staff.

Performance Effects Summary

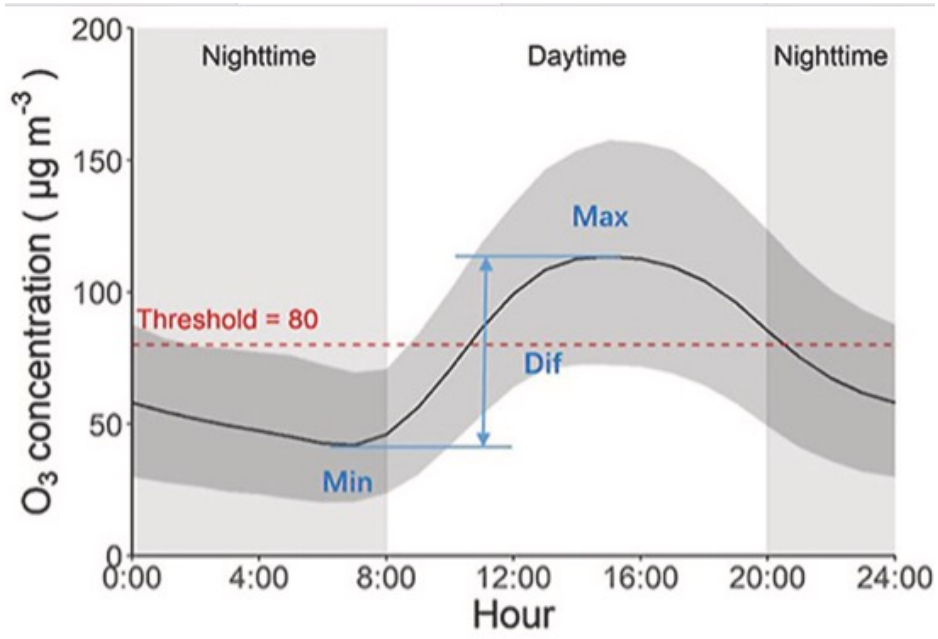
- Ozone
  - Decreased VO2max during exercise
  - Decreased running performance
  - Symptoms increased
  - Adaptation?

- TRAP and DE
  - inconsistent performance effects
    - Possible increased symptoms
    - Possible increased HR and metabolic cost

Pollution in Time

The diurnal cycle of summer tropospheric ozone concentrations across Chinese cities: Spatial patterns and main drivers☆

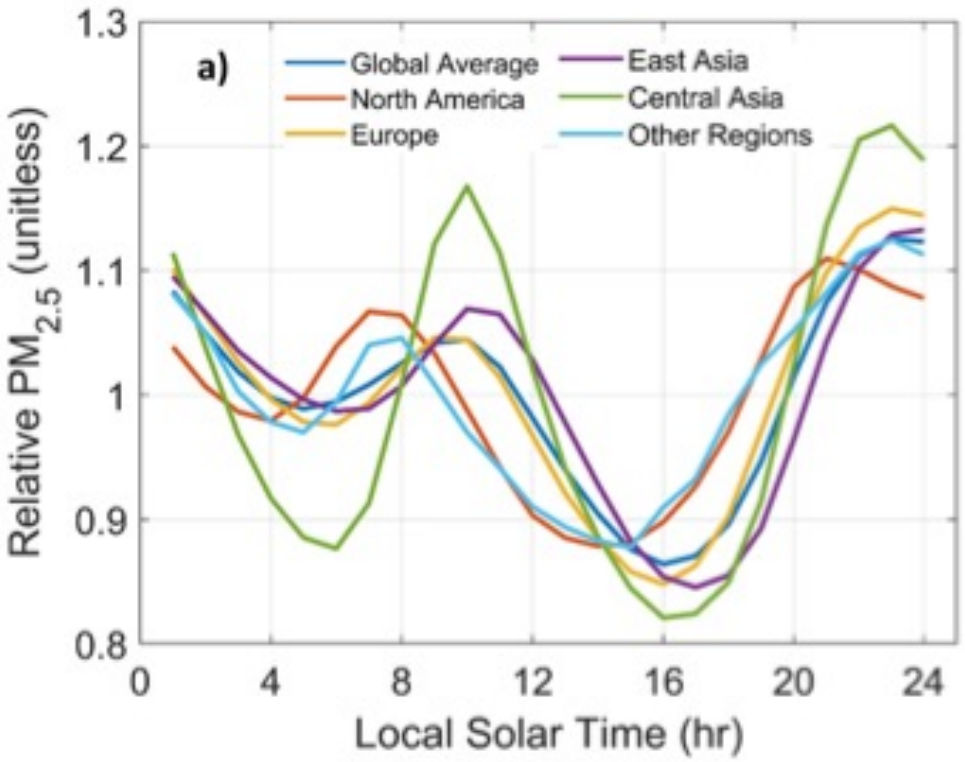
Nan Xia [a,b], Enzai Du [a,b,*], Zhaodi Guo [c], Wim de Vries [d,e]



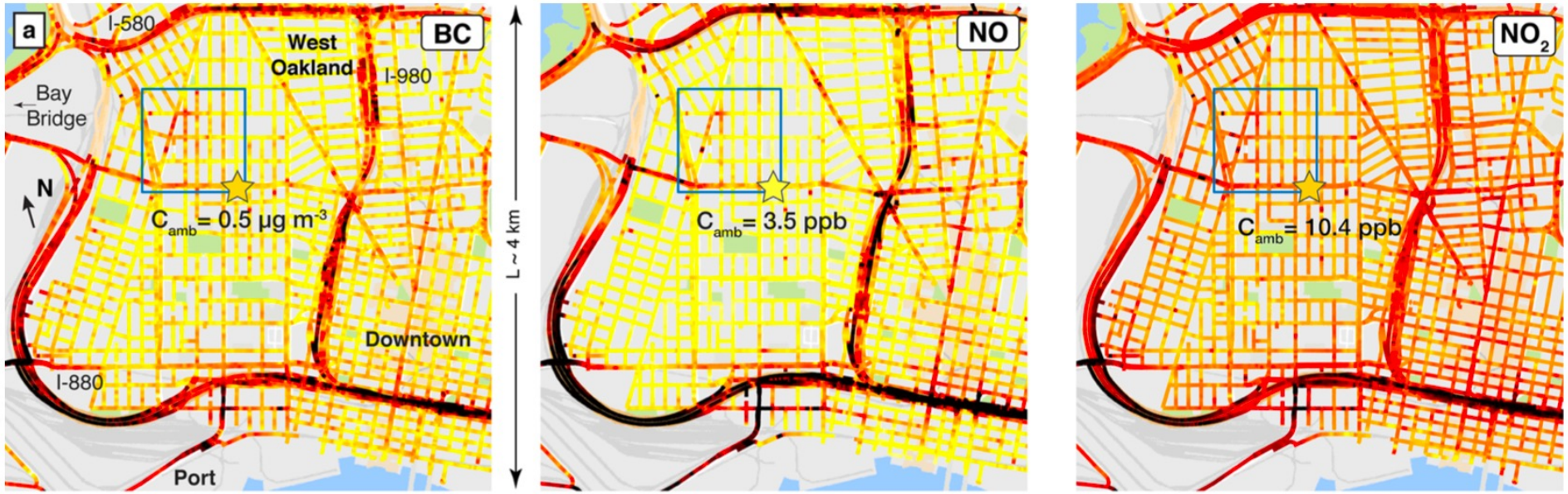
ENVIRONMENTAL Science & Technology LETTERS
Letter
Cite This: Environ. Sci. Technol. Lett. 2018, 5, 687−691
pubs.acs.org/journal/estlcu

Diurnal Patterns in Global Fine Particulate Matter Concentration

Max I. Manning,*[†] Randall V. Martin,[†,‡] Christa Hasenkopf,[§] Joe Flasher,[§] and Chi Li[†]



Air Pollution Location Effects



Legend

BC (µg m^{-3})

0 0.5 1.0 1.5 2.0

0 10 20 30 40

NO, NO_2 (ppb)

★ = concentration C_{amb} at fixed-site monitor

Masks

- Limited research
  - Studies of walking in Beijing
  - Wearing masks for 48 hours
  - Some HRV and SBP changes
- 3M 8812 recommended
  - ~3% penetrance of Diesel
  - Comfortable to wear
  - Langrish et al. 2009

- Recommended for high particulate sites
  - When not training

anses
agence nationale de sécurité sanitaire
alimentation, environnement, travail
Connaître, évaluer, protéger

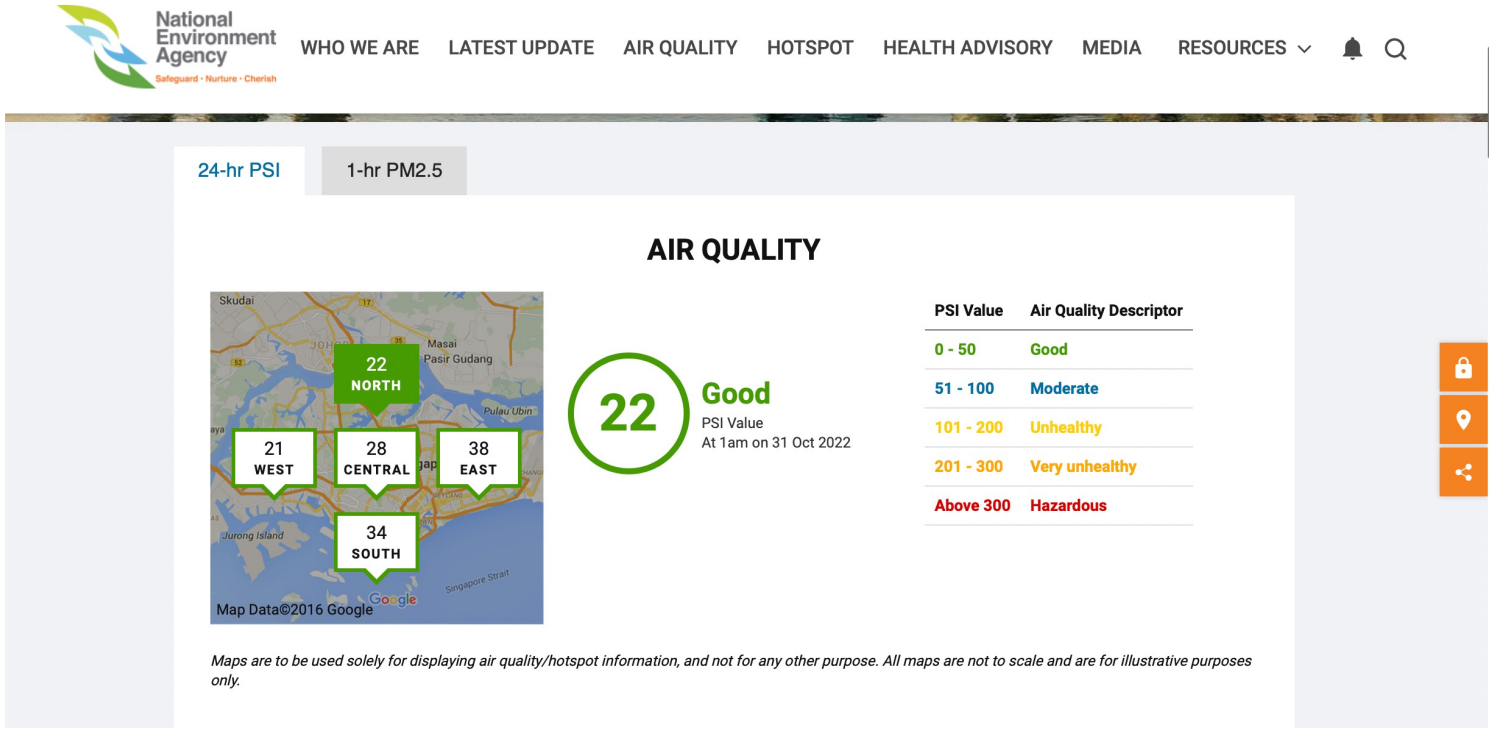
Évaluation du bénéfice sanitaire attendu de dispositifs respiratoires dits antipollution

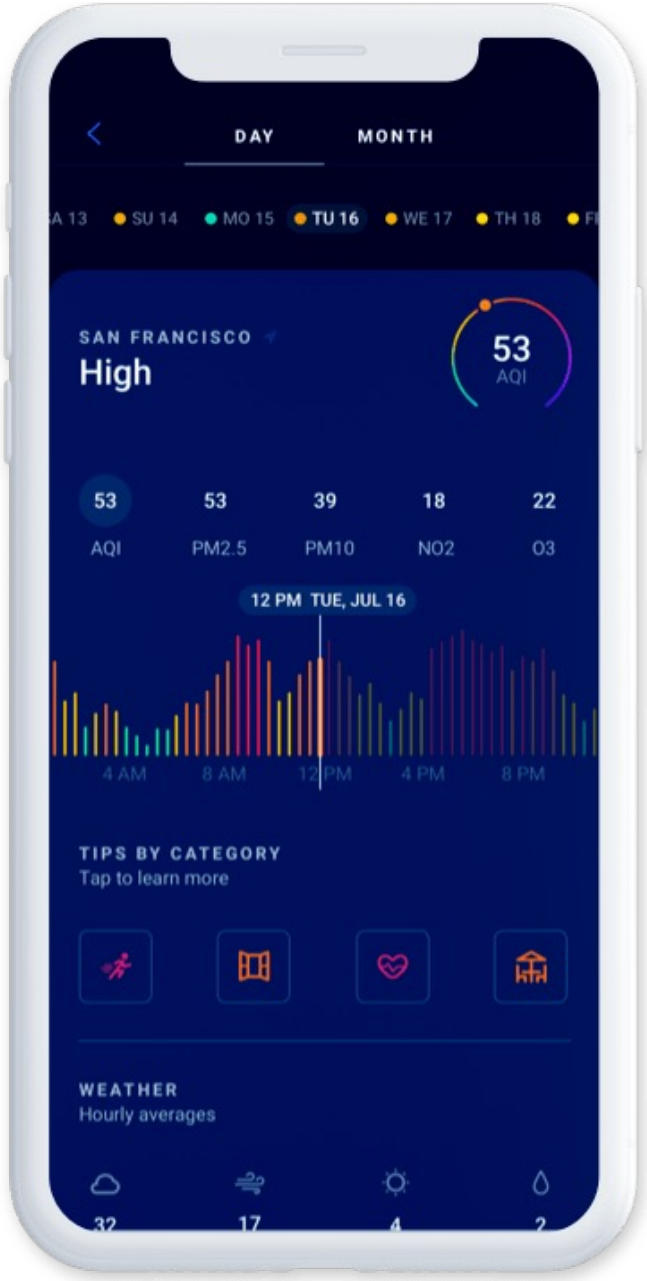
Avis de l'Anses
Rapport d'expertise collective

Mai 2018 Édition scientifique

Monitoring/Forecasting

- haze.gov.sg, Plume App





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Competition Recommendations - Ozone

- Avoid pollution as much as possible pre- competition
  - Travel to and from competition
- Stabilize asthma and EIB with medications and proper warm-up
- Anticipate symptoms: chest tightness, dyspnoea
- Some evidence that anti-oxidants may decrease ozone effects
  - 2 weeks of:
    - Vitamin C 250-500 mg OD
    - Vitamin E 100 mg OD
- Consider Adaptation

TOKYO 2020

Competition Recommendations for primarily PM/TRAP

- Avoid pollution as much as possible pre- competition
  - Travel to and from competition
- Stabilize asthma and exercise-induced bronchoconstriction with medications and proper warm-up
- Reassurance on performance
  - Minimal performance effects during competition

- Consider masks that filter particulate in very high pollution environments

IAAF World Athletics Championships
DOHA2019™

Training Recommendations

- Check Pollution Forecast
- Avoid pollution as much as possible
  - Separate by time
  - Separate by distance
  - **Minimise non-exercise pollution exposure**

- On high pollution days
  - Shorter, more intense workouts
  - Move training to better environment
  - Extra care in those with respiratory disease
    - Salbutamol/albuterol safe in asthma and exercise induced bronchoconstriction


HEAT

The 2022 Europe report of the *Lancet* Countdown on health and climate change: towards a climate resilient future

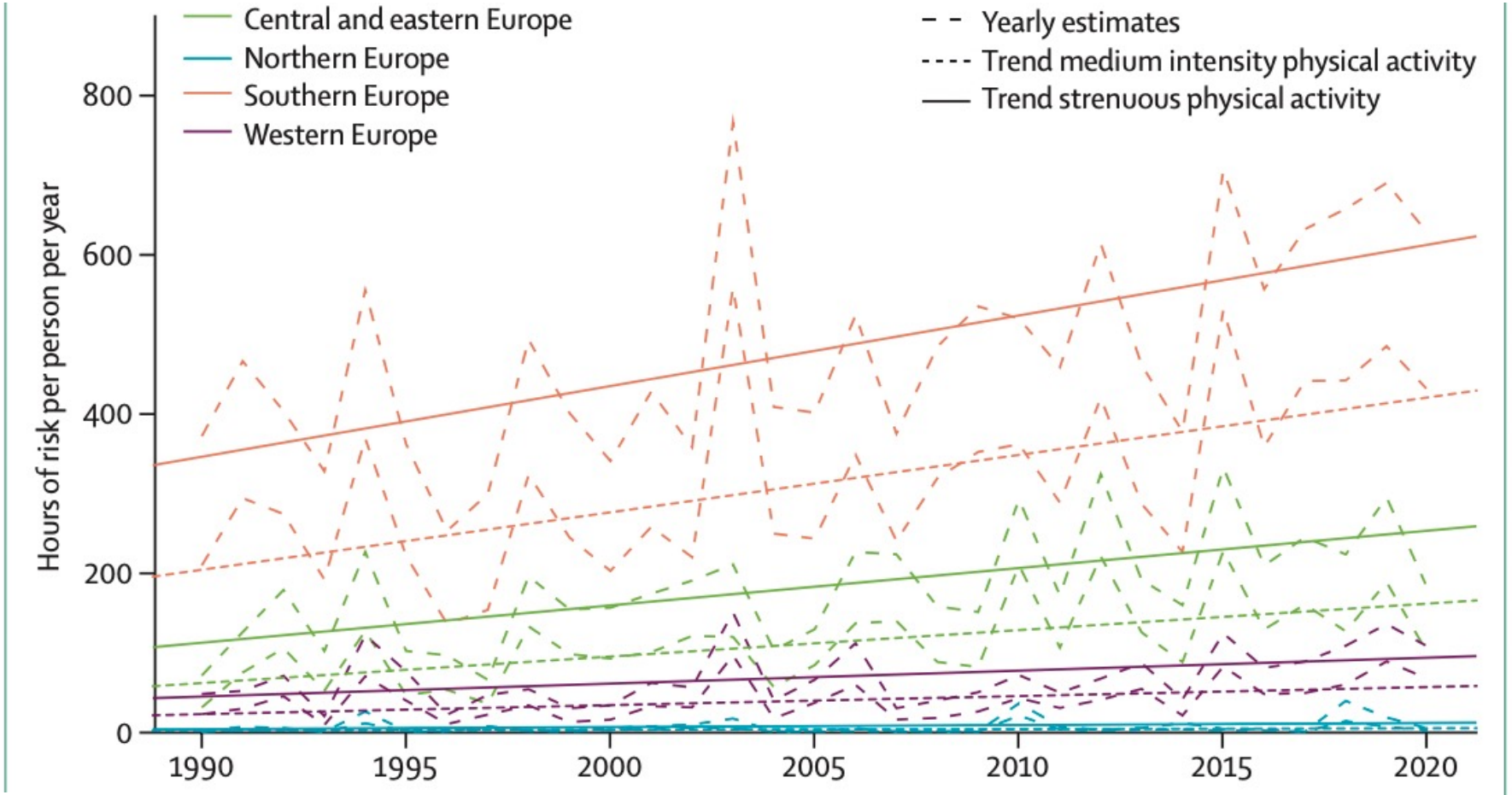


Figure 1: **Heat and human health in Europe**

(A) Hours of risk per person per year (1990–2020) with 95% confidence intervals for physical-activity-related heat stress per European region, for activities of medium and high intensity.

Tokyo Environmental Conditions and Performance

Athlete Medical Services at the Marathon and Race Walking Events During Tokyo 2020 Olympics

Makoto Sugawara [1,2], Yoshiaki Manabe [1,3], Fumihiro Yamasawa [1,4] and Yuri Hosokawa [5]*

[1] Medical Committee, Japan Association of Athletics Federations (JAAF), Tokyo, Japan, [2] Matsuda Orthopedic Memorial Hospital, Sapporo, Japan, [3] Department of Sports Science, Chukyo University, Nagoya, Japan, [4] Marubeni Health Promotion Center, Tokyo, Japan, [5] Faculty of Sport Sciences, Waseda University, Saitama, Japan

TABLE 2 | Percentage of athletes who did not finish (%DNF).

Event	Number of finishers	Number of DNF	%DNF	Completion rate
Men's 20 km race walk	52	5	8.8%	91.2%
Women's 20 km race walk	53	5	8.6%	91.4%
Men's 50 km race walk	47	12	20.3%	79.7%
Men's marathon	76	30	28.3%	71.7%
Women's Marathon	73	15	17.0%	83.0%

DNF, did not finish.

Tokyo Environmental Conditions and Performance

	Temp	Humid	Humidex
6am	25	85%	34
7am	27	80%	37
8am	28	80%	39
9am	31	75%	44
9:30am	33	65%	45
	% of PB	% of SB	Min PB
Medalists	-2.5%		
Top 8	-2.7%		
Entire Field	-6.7%		

	Temp	Humid	Humidex
6am	26C	79%	35
7am	27C	70%	35
8am	28C	67%	36
9am	29C	66%	38
	% of PB	% of SB	Min PB
Medalists	-5.9%		-8.72
Top 8	-5.3%		-7.87
Entire Field	-6.6%		-10.58

Three Pillars of Performance in the Heat

- Heat Acclimation/Acclimatization
- Heat Mitigation
  - Pre-event
  - Per-event
- Hydration Strategy

Acclimation/acclimatisation

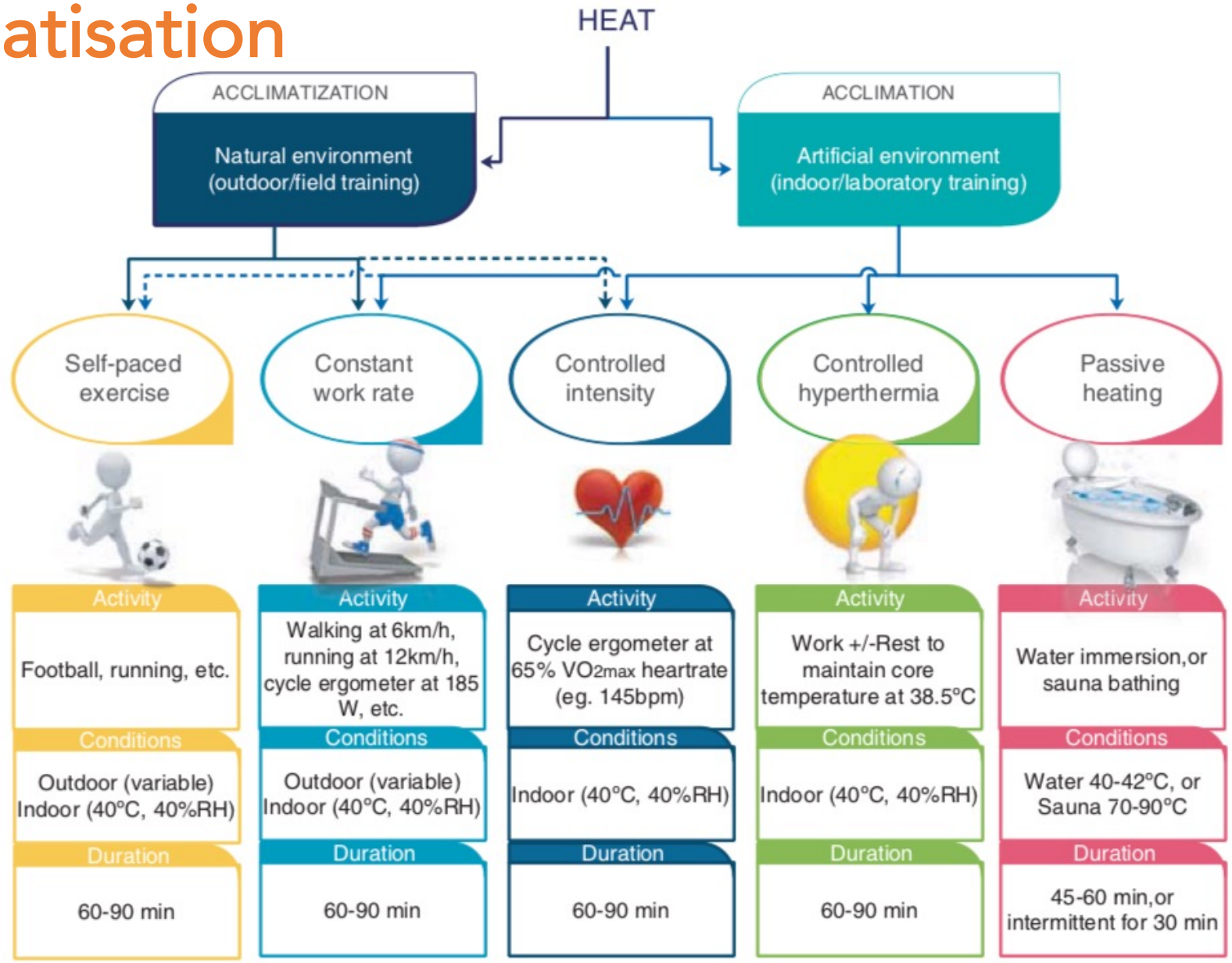
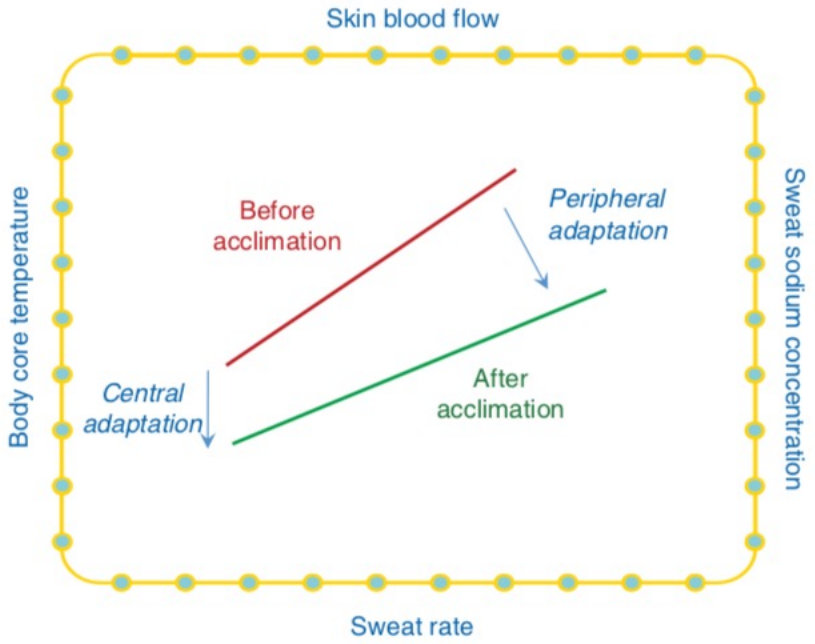


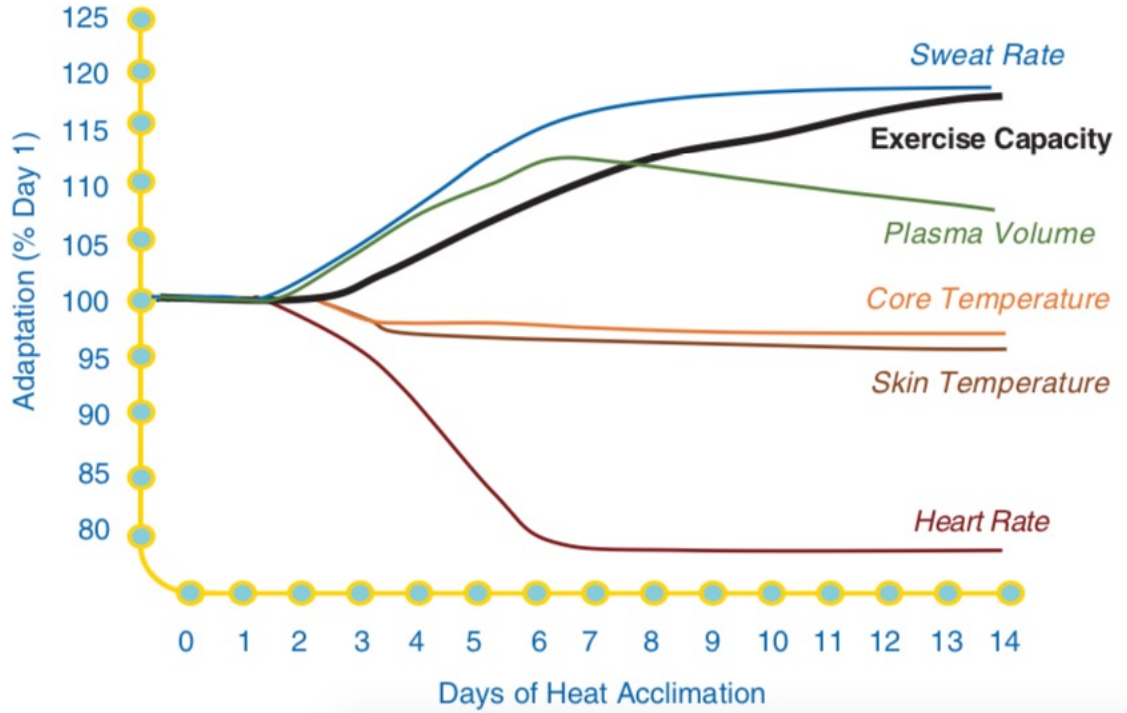
Fig. 8.5 Overview of heat acclimation methods. Based on Daanen et al. [121]

J. D. Périard, S. Racinais (eds.), *Heat Stress in Sport and Exercise*, https://doi.org/10.1007/978-3-319-93515-7_8

Acclimation

Fig. 8.1 Heat acclimation lowers the core temperate threshold for sweating and increases the rate and sensitivity of response. Heat acclimation decreases also sweat sodium concentration. Based on Periard et al. [3]





J. D. Périard, S. Racinais (eds.), *Heat Stress in Sport and Exercise*, https://doi.org/10.1007/978-3-319-93515-7_8

Heat Acclimation

J. D. Périard, S. Racinais (eds.),
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https://doi.org/10.1007/978-3-319-93515-7_8

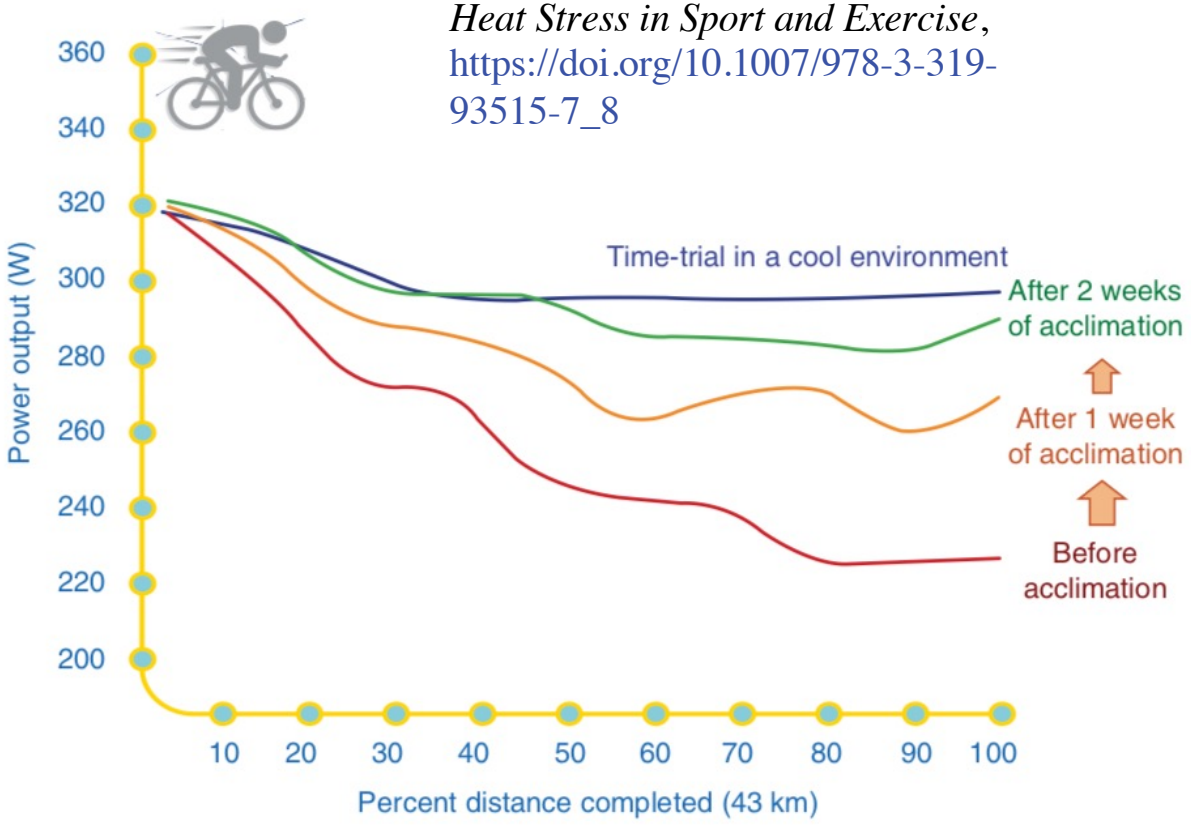


Fig. 8.7 Power output during a 43 km cycling time trial in cool ambient conditions (blue line) and in hot ambient conditions on the first (red line), the 6th (orange line), and the 14th (green line) days of heat exposure. Based on data from Racinais et al. [100]

The Efficacy of Heat Acclimatization Pre-World Cup in Female Soccer Players

César M. P. Meylan[1,2,3], Kimberly Bowman[2], Trent Stellingwerff[2,3], Wendy A. Pethick[3], Joshua Trewin[1,4] and Michael S. Koehle[2]*

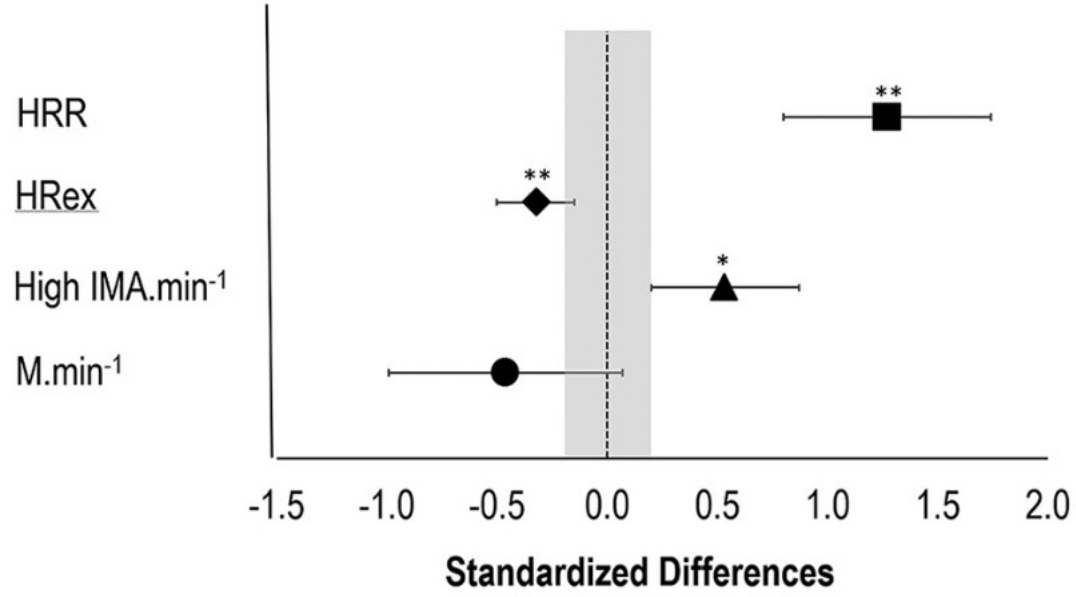


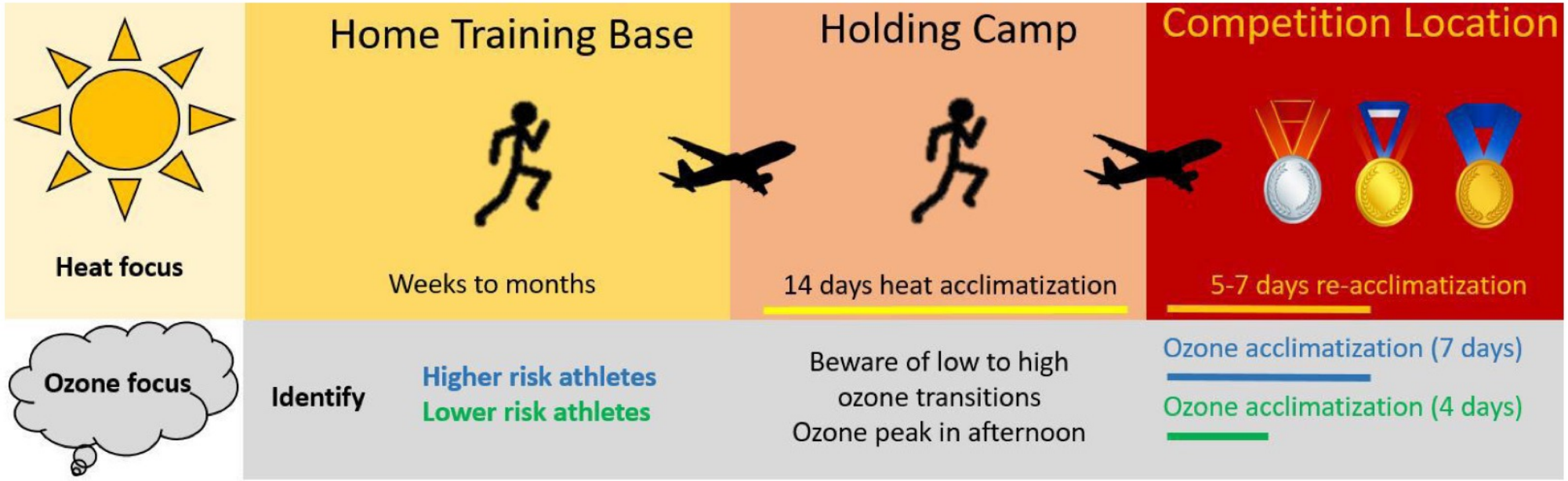
FIGURE 6 | Standardized differences (±90% confidence intervals) in physical performance during a four-a-side small-sided soccer game played in phase 2 in Cancun on day 9 (36°C–36% RH) and the last day of phase 2 on day 14 (35°C–50%RH). The shaded gray area represents trivial differences (i.e., <0.20). *Significant difference ($p < 0.05$ and **$p < 0.01$) between day 9 and day 14. HRR, HR recovery; HRex, HR at exercise; high IMA min^{-1}, number of high inertial movement action (>2.5 m s^{-2}) per minute; m min^{-1}, meters per minute.

Acclimatisation Camp

- Heat acclimatisation
- Hydration experimentation
- Hydration/Cooling practice
- Relationship building
- Minimisation of distractions

- Ozone acclimatisation?

Ozone and Heat



Athlete performance checklist		Athlete health checklist	
➢ Heat/humidity gauge	☐	➢ Medication	☐
➢ Cloud cover forecast	☐	➢ Individual symptom time course	☐
➢ Acclimatization plan	☐	➢ Travel/Jet lag	☐

Figure 1 Summary of how to concurrently prepare to compete in the heat with high levels of ozone. An athlete performance and health checklist for science and medicine staff.

Precooling
Percooling

Taylor L, *et al*. *Br J Sports Med* November 2020 Vol 54 No 21

Pre Cooling

- Immersion – torso
  - 10-15C
- Vests
- Slushies/cool drinks
- Avoid shivering

- Shorter warm-up

Per Cooling

- Ice cold drinks (water/electrolyte)
- Ice cold towels
- Ice cold hats
- Ice necklaces

Hydration

Hydration for the Tokyo Olympics: to thirst or not to thirst?

Julien D Périard [1], Thijs Eijsvogels [2], Hein A M Daanen [3], Sebastien Racinais [4]

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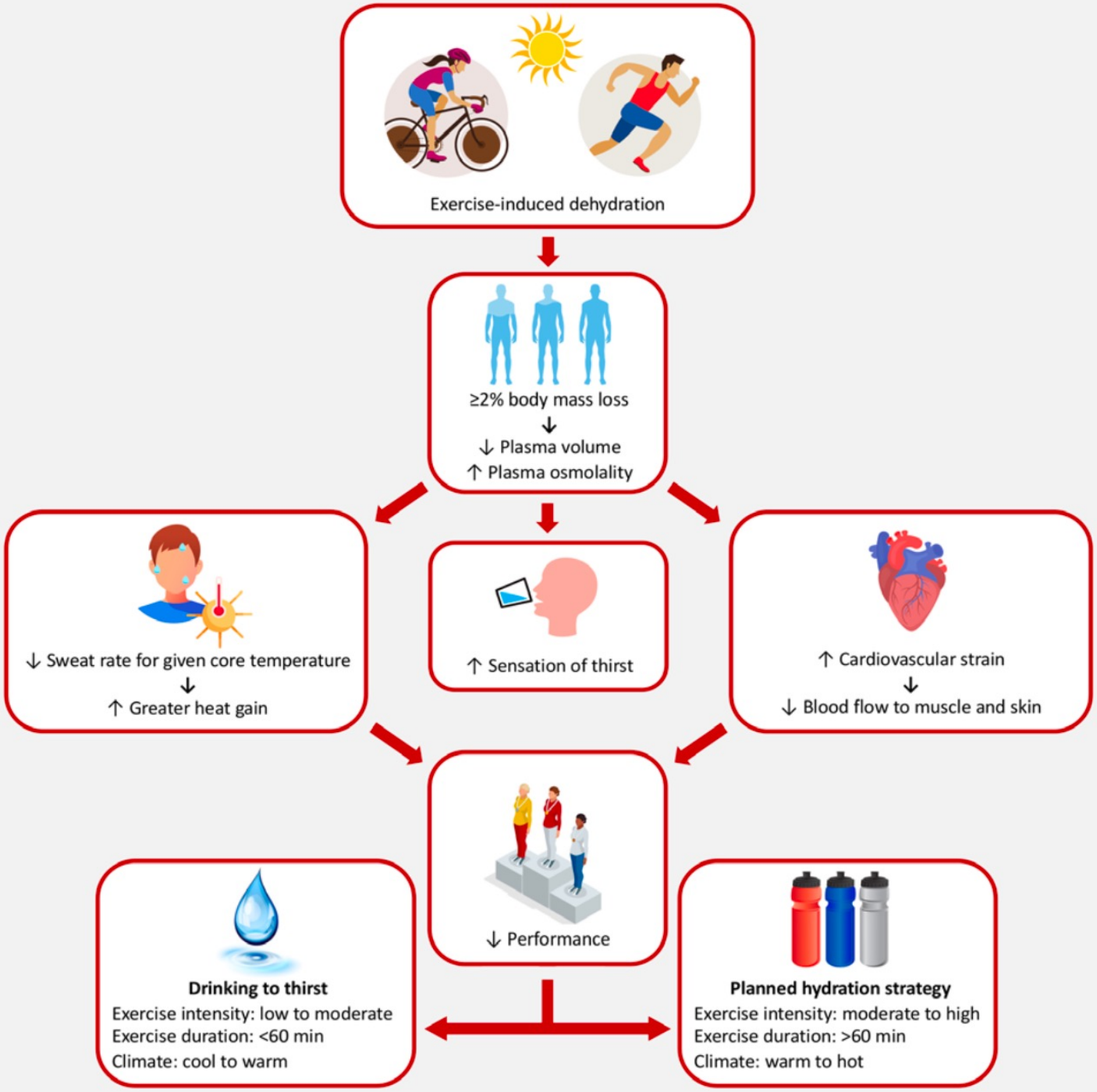


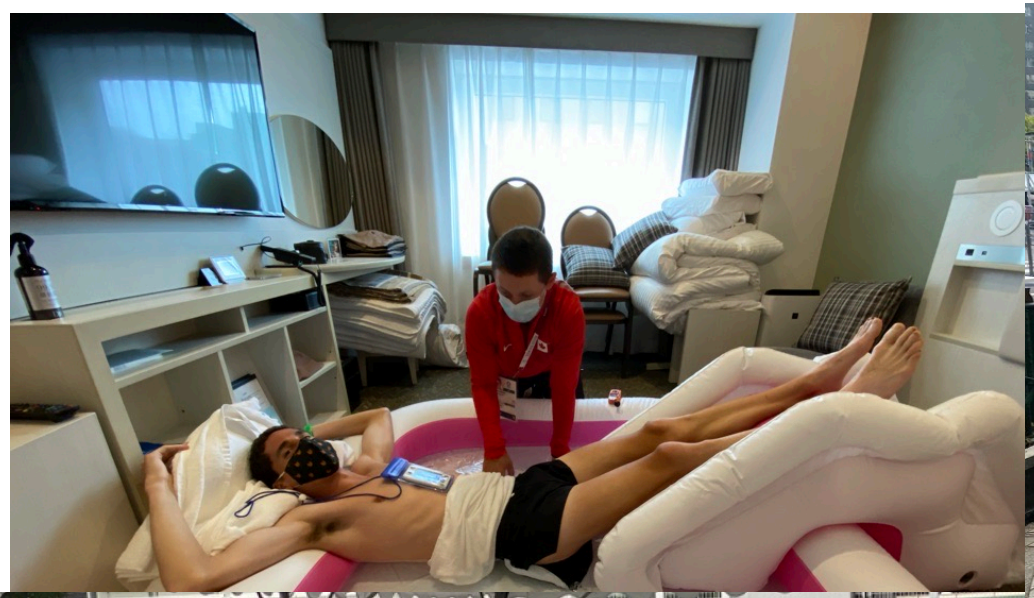
Hydration Planning

- Fluid tolerability/concentration
- Hand offs
- Team Communication
- Athlete SST Individual Meetings
- Discuss and Plan Contingencies

Logistics – Plan Ahead

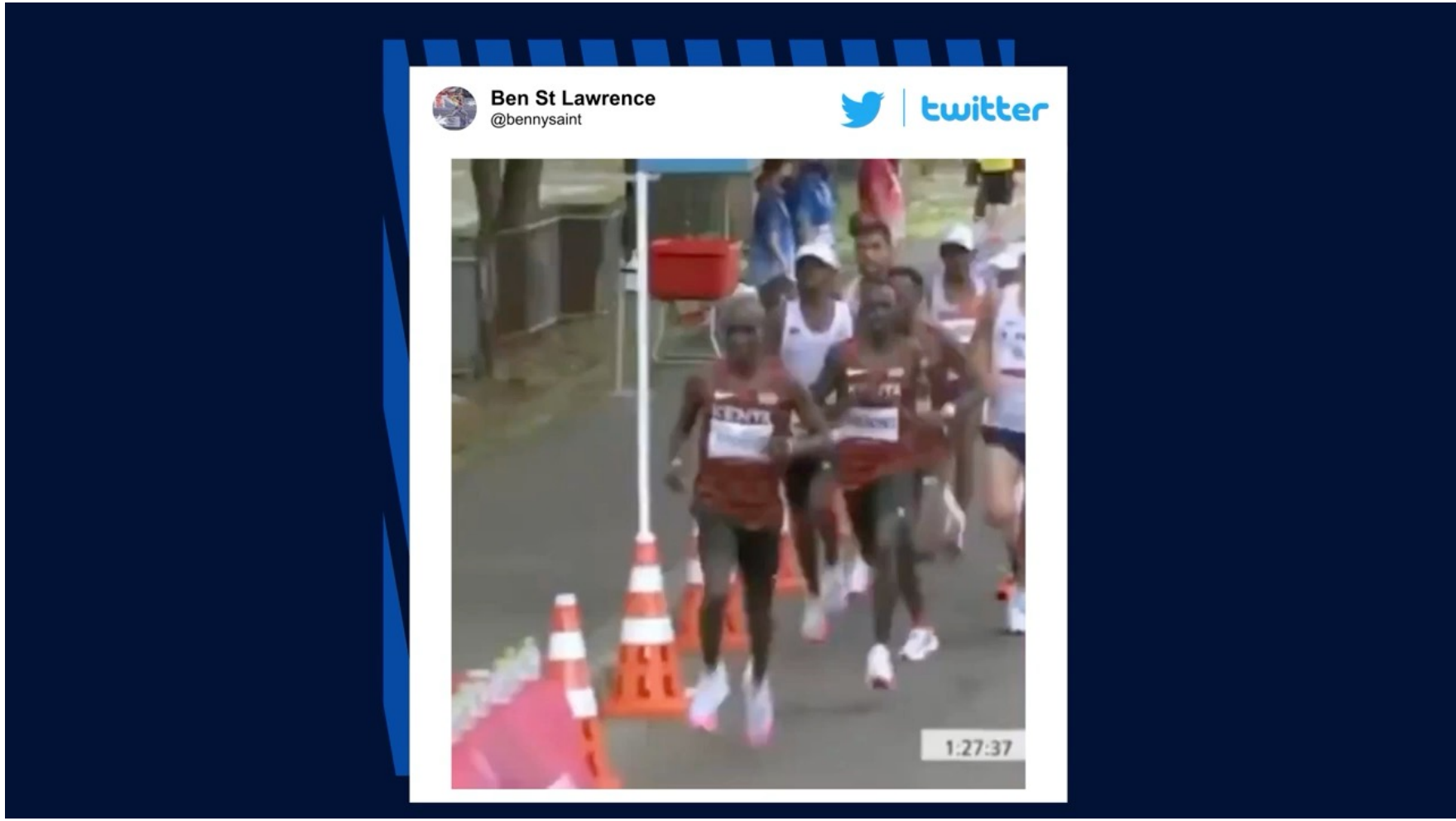
- Site visit
- Supplies/Equipment
- Water/ice
- Familiarisation
- Practice handoffs

- AVOID
  - Shivering
  - GI distress



Kipchoge's Bottle Man- Claus-Henning Schulke

Hydration



Take Home Messages

- Monitor Environmental Conditions and Forecasts – Separate in Time and Space
- Always consider the relevant Air Pollution Recipe - Adapt your strategy to this Recipe
- Employ a Three-Pronged Strategy for Heat - Acclimation, Mitigation, Hydration

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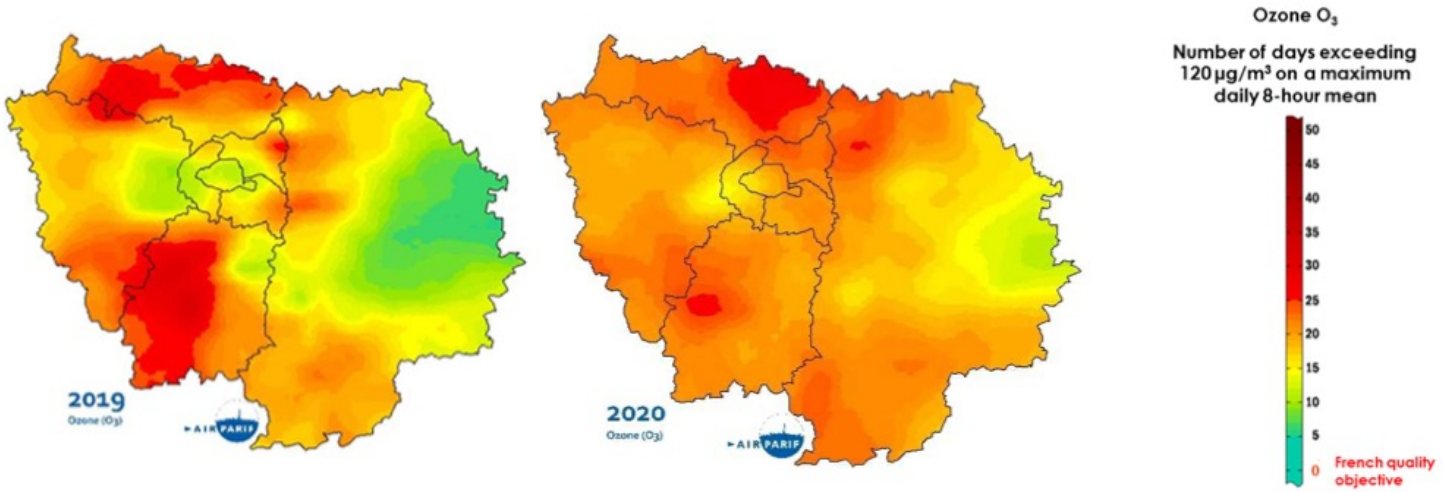
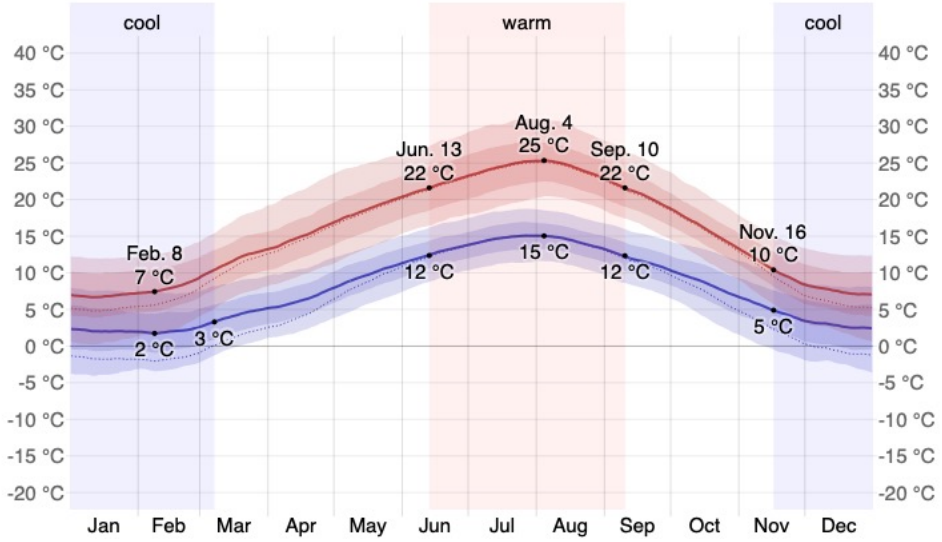
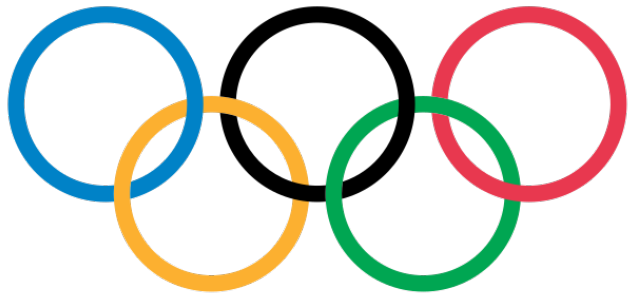


Figure 22: number of days exceeding the French quality objective (=EU long-term objective) threshold of 120 µg/m³ on a maximum daily 8-hours mean (objective = no exceedance) for ozone (O_3) in the Paris region in 2020



PARIS 2024



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Contact:

Socials: @mskoehle

Email: michael.koehle@ubc.ca