





Please cite the Published Version

Detraux, Luke A. , Diaz Avalos, Alonzo R. , Faraggi, Alon E.  and Percival, Benjamin 
(2024) Vacuum energy of nonsupersymmetric \sim S heterotic string models. Physical Review D, 110 (8). 086006 ISSN 2470-0029

DOI: <https://doi.org/10.1103/physrevd.110.086006>

Publisher: American Physical Society (APS)

Version: Published Version

Downloaded from: <https://e-space.mmu.ac.uk/636153/>

Usage rights:  [Creative Commons: Attribution 4.0](https://creativecommons.org/licenses/by/4.0/)

Additional Information: This is an open access article which first appeared in Physical Review D, published by American Physical Society (APS)

Enquiries:

If you have questions about this document, contact openresearch@mmu.ac.uk. Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)

Paris and pollution, heats in the heat: a topical discussion of the relationship between the climate and sport

Daniel Tinnion ¹, Amy Harwood ², Evert Verhagen ³,
Carole Akinyi Okoth ^{4,5}, Diana Gai Robinson ^{6,7}

To cite: Tinnion D, Harwood A, Verhagen E, *et al.* Paris and pollution, heats in the heat: a topical discussion of the relationship between the climate and sport. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e002249. doi:10.1136/bmjsem-2024-002249

Accepted 12 September 2024



© Author(s) (or their employer(s)) 2024. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Life Sciences, Manchester Metropolitan University, Manchester, UK

²Department of Sport and Exercise Sciences, Manchester Metropolitan University, Manchester, UK

³Department of Public and Occupational Health, EMGO, Amsterdam UMC Locatie VUmc, Amsterdam, Netherlands

⁴Internal Medicine/ Rehabilitation, National Spinal Injury Referral Hospital, Nairobi, Kenya

⁵Directorate of HealthCare Services, Ministry of Health, Kenya, Nairobi, Kenya

⁶Sport and Exercise Medicine, Sydney Sportsmed Specialists, Sydney, New South Wales, Australia

⁷STP Education Projects, Australasian College of Sport and Exercise Physicians, Melbourne, New South Wales, Australia

Correspondence to
Dr Daniel Tinnion;
D.Tinnion@mmu.ac.uk

Whether by social media app or newspaper, rarely a day passes without a story about the environment and its relationship with athletic performance, policy and physical activity. The latest instalment of the Summer Olympics, Paris 2024 saw climate change take centre stage once more as the French city promised the most sustainable games to date.¹ Starting on 24 July, they may also prove to be the hottest games to date, exceeding the 34°C experienced at Tokyo 2020² and raising the question once more...are the Summer Games really sustainable?

THE BURNING ISSUE

Since Paris last hosted the Olympics in 1924, annual temperatures have increased by 1.8°C, giving rise to an average of 23 more ‘hot’ (25°C +) days and 9 more ‘scorching’ (30°C +) days per year.² As highlighted in the Rings of Fire II Report, dismissing the impact of heat would be a mistake despite the Olympics predominantly taking place in the north. Climate change from human activities increases the likelihood of heatwaves, translating to a 70% increase in heat-related mortality risk.³ In the summer of 2003, a heatwave killed more than 14 000 people across France.⁴ At the time, the maximum temperature recorded in Paris was 39.5°C, now sitting at 42.6°C since 2019.⁵ As a result, ‘scorching’ summers, just like 2003, are now 10 times more likely due to climate change⁶ and going nowhere fast. Last summer, temperatures in Europe and across France were impacted significantly by the Cerberus heatwave, with a high of 42.6°C and almost 5000 deaths.⁷ Understandably, there is a growing concern for athletes also facing exertional heat stress, best reflected in the words of Daniil Medvedev: “I’m a fighter. I will finish the match, but I can die,” he said. “If I die, is the ITF (International Tennis Federation) going to take (sic) responsible?”⁸

THE SPORT–CLIMATE RELATIONSHIP

As the climate crisis impacts sport, sport impacts the climate crisis. Devrika Rao of The Week US observes: “From the greenhouse gases emitted from transporting equipment, athletes and fans all over the world” ... “to the harm done to ecosystems by venue construction, high-density events and poor waste management” ... it’s clear that the athletic sector has played a role in the worsening climate crisis.⁹ In one example, flying ~29 000 athletes and staff to Brazil for the 2016 Rio Olympics generated 2000 kilotons of greenhouse gases. Notwithstanding the additional 2500 kilotons associated with transporting ~500 000 global spectators.¹⁰ An emerging body of research has linked air pollutants like ozone and sulphur dioxide to increased bronchoconstriction and airflow obstruction during exercise, compared with the same pollution exposure at rest.¹¹ A 2022 study found that higher air pollution levels also predicted increased errors and interceptions in professional baseball and American football.¹² Further research in Major League Baseball noted that a 1 part per million increase in carbon monoxide levels over 3 hours caused an 11.5% increase in umpires’ likelihood to make an incorrect call.¹³ All this is to say nothing of the general health burden of air pollution that may impact spectators and individuals in their daily lives.¹⁴

AN ECOLOGICAL SHIFT?

The International Olympic Committee has made moves in an attempt to ‘green’ the games. As part of its sustainability strategy, the five key areas of infrastructure, material sourcing, mobility, workforce and climate underpin an attempt to reduce the environmental footprint associated with construction and transportation and to leave the host city with a better infrastructure.¹⁵ Despite this guidance, sustainability is not always delivered. For

example, the organisers of Rio 2016 promised to restore the city's waterways through investments in sanitation; however, many of them were littered with rubbish only a year later.¹⁶ Indeed, due to concerns around water quality in the River Seine, Paris 2024 saw the postponement of multiple triathlon events, with three athletes also falling ill after the 10 km open water swimming event.¹⁷ While the lasting effects of hosting the Olympics remain to be seen, Mike Gagliardi of NBC News (USA) highlights that Paris is noticeably different compared with 10 years ago, primarily due to its policy on reducing car dependence. Paris has closed 100+ streets to motor vehicles, tripled SUV parking fees, removed ~50 000 parking places and added 1300 km of bike lanes since Mayor Anne Hidalgo took office in 2014.¹⁸ City officials report that this has aided a 40% decline in air pollution.¹⁸ The aim of Paris 2024 was to host more responsible games, contributing to an ecological shift in the world of sports and events, which may still prove to float.¹⁹

From our perspective in sport and exercise medicine, an ecological shift may start by improving our understanding of the impact of environmental factors such as heat on athlete performance, illness and injury. It then may grow into developing or influencing policy/guidelines and shaping future practice. From here, a more comprehensive change would consider spectator well-being and the broader impacts of environmental factors such as air pollution on health or physical activity. This topic collection encompasses several articles across this space, aiming to play a small part at the intersection between climate and athletic performance, policy and physical activity.

X Daniel Tinnion @Dan_Tinnion, Amy Harwood @AmyHarwood91, Evert Verhagen @evertverhagen, Carole Akinyi Okoth @Carole0683 and Diana Gai Robinson @dianarobdoc

Contributors EV and AH formulated the idea. All authors contributed to the design of the manuscript. DT conducted the literature review and wrote the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content and approved the submitted manuscript. DT is the guarantor of this work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Commissioned; internally peer reviewed.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Daniel Tinnion <http://orcid.org/0000-0002-3116-0985>
 Amy Harwood <http://orcid.org/0000-0002-5745-2564>
 Evert Verhagen <http://orcid.org/0000-0001-9227-8234>
 Carole Akinyi Okoth <http://orcid.org/0009-0005-1187-4250>
 Diana Gai Robinson <http://orcid.org/0000-0002-2627-2309>

REFERENCES

- International Olympic Committee. Less, better and for longer: five ways Paris 2024 is delivering more sustainable games. 2024. Available: <https://olympics.com/ioc/news/less-better-and-for-longer-five-ways-paris-2024-is-delivering-more-sustainable-games>
- Doherty B. Athletes warn 'hottest games on record' could threaten lives at Paris Olympics. 2024. Available: <https://www.theguardian.com/sport/article/2024/jun/18/paris-olympics-2024-weather-summer-temperatures-extreme-heat>
- Stott PA, Stone DA, Allen MR. Human contribution to the European heatwave of 2003. *Nat New Biol* 2004;432:610–4.
- Dhainaut JF, Claessens YE, Ginsburg C, et al. Unprecedented heat-related deaths during the 2003 heat wave in Paris: consequences on emergency departments. *Crit Care* 2004;8:1–2.
- Berlinger J. Nearly 1,500 deaths linked to French heat waves. 2019. Available: <https://edition.cnn.com/2019/09/08/europe/france-heat-wave-deaths-intl-hnk-scli/index.html>
- Christidis N, Jones GS, Stott PA. Dramatically increasing chance of extremely hot summers since the 2003 European heatwave. *Nature Clim Change* 2015;5:46–50.
- Goar M. Paris 2024: risk of heatwave raises fears of a stifling games. 2024. Available: <https://archive.ph/dstzb>
- Guy J. Daniil medvedev asks who will take responsibility if he dies in Tokyo Olympics' heat and humidity. 2021. Available: <https://edition.cnn.com/2021/07/28/sport/tokyo-olympics-heat-humidity-spt-scli-intl/index.html>
- Rao D. How climate change is impacting sports around the world. 2023. Available: <https://theweek.com/environment/climate-change-impacting-sports>
- Dendura B. Olympic Infrastructure—Global Problems of Local Communities on the Example of Rio 2016, PyeongChang 2018, and Krakow 2023. *Sustainability* 2023;12:141.
- Pierson WE. Impact of air pollutants on athletic performance. *Allergy Proc* 1989;10:209–14.
- Heintz EC, Scott DP, Simms KR, et al. Air Quality Is Predictive of Mistakes in Professional Baseball and American Football. *Int J Environ Res Public Health* 2022;20:542.
- Archsmith J, Heyes A, Saberian S. Air Quality and Error Quantity: Pollution and Performance in a High-Skilled, Quality-Focused Occupation. *J Assoc Environ Resour Econ* 2018;5:827–63.
- Sigsgaard T, Hoffmann B. Assessing the health burden from air pollution. *Science* 2024;384:33–4.
- International Olympic Committee. The IOC sustainability strategy. 2020. Available: <https://olympics.com/ioc/sustainability>
- Balch O. Funding problems hit plan to clean rio's polluted waterways ahead of Olympics. 2016. Available: <https://www.theguardian.com/sustainable-business/2016/feb/01/funding-problems-hit-plan-clean-rios-polluted-waterways-olympics>
- Lee B. 3 German swimmers ill after racing in Seine river at Paris Olympics. *Forbes.com*, 2024. Available: <https://www.forbes.com/sites/brucelee/2024/08/11/3-german-swimmers-ill-after-racing-in-seine-river-at-paris-olympics/>
- Gagliardi M. What does a city that has spurned cars look like? olympics visitors to paris will get a look. 2024. Available: <https://www.nbcnews.com/science/environment/paris-olympics-city-reduce-air-pollution-rcna153470>
- Paris. The cnosf and the french ministry of sport introduce new tool to help sporting events reduce their carbon footprint. 2024. Available: <https://press.paris2024.org/news/paris-2024-the-cnosf-and-the-french-ministry-of-sport-introduce-new-tool-to-help-sporting-events-reduce-their-carbon-footprint-524e-7578a.html>