Tracking safe exercise levels in a warming world: a global and regional analysis

Samuel H. Gunther[a,b], Pearl M. S. Tan[a,b], Bruno Lemke[c], Chris Freyberg[d], Matthias Otto[c], Tord Kjellstrom[e], Jason K. W. Lee[a,b,f,g]

[a] Human Potential Translational Research Programme, Yong Loo Lin School of Medicine, National University of Singapore
[b] Campus for Research Excellence and Technological Enterprise (CREATE), Singapore [c] Nelson Marlborough Institute of Technology, Nelson, New Zealand
[d] Ruby Coast Research Centre, Health and Environment International Trust, Mapua, New Zealand [e] Heat and Environment International Trust, Nelson, New Zealand
[f] Department of Physiology, Yong Loo Lin School of Medicine, National University of Singapore [g] Global Asia Institute, National University of Singapore

Introduction

Regular physical activity carries numerous benefits, including **lower risk of cardiometabolic disease and cognitive decline**. However, the desire to engage in exercise is significantly affected by the thermal environment, with **warm ambient conditions** corresponding to **shortened duration** of and **lower engagement** in physical exercise. Furthermore, the occurrence of **conditions unsafe for outdoor exercise** due to heat stress risk is **increasing due to climate change**.

Methods

Hourly **temperature** and **relative humidity** records from ERA5 were combined with gridded **population** data from NASA to determine the total number of **hours per person per day** from 1991 to 2022 in which **outdoor exercise carried a 'high' risk of heat stress**, per Sports Medicine Australia guidelines.

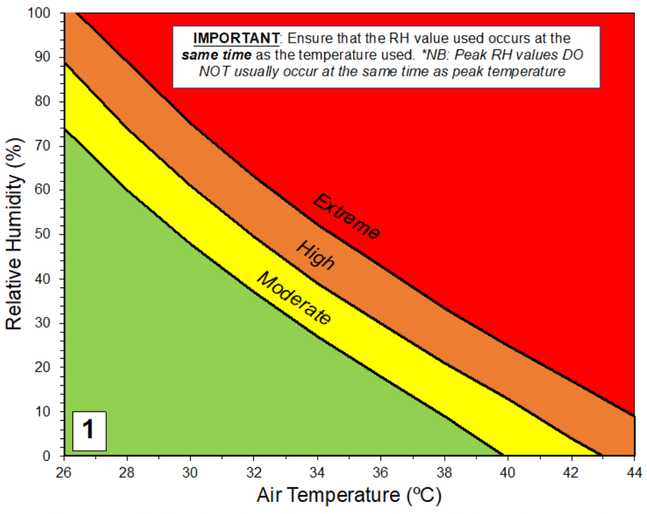

Figure 1 Risk function describing low, moderate, high, and extreme heat stress cutoffs for low-intensity exercise, Sports Medicine Australia, 2021

Results

Globally, the total number of unsafe outdoor exercise hours per person per day **increased** from **3.07 in 1991** to **3.50 in 2022**. However, the burden of increasing outdoor heat stress was **not evenly distributed** among geographic regions. **Tropical, equatorial countries experienced more** while **temperate, polar countries experienced less**.

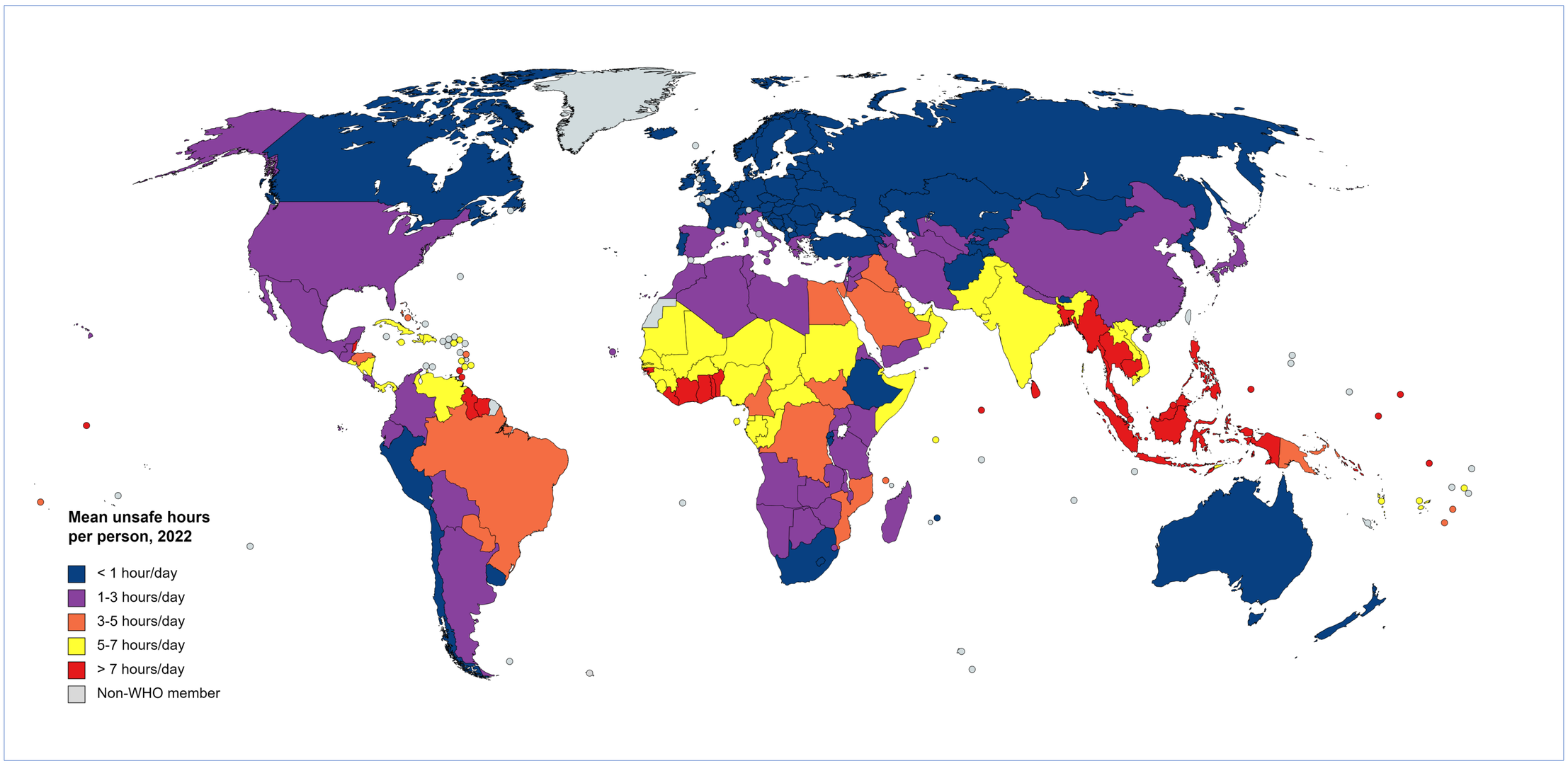

Figure 2 Global map comparing total number of unsafe outdoor exercise hours per person per day in each WHO member state, 2022

Case study: Singapore

Unsafe exercise hours per person per day in Singapore **increased** from **8.45 in 1991** to **9.28 in 2022**, **significantly higher** than the global average. However, **local peaks** in 1998, 2010, 2016 and 2018 **followed global trends**.

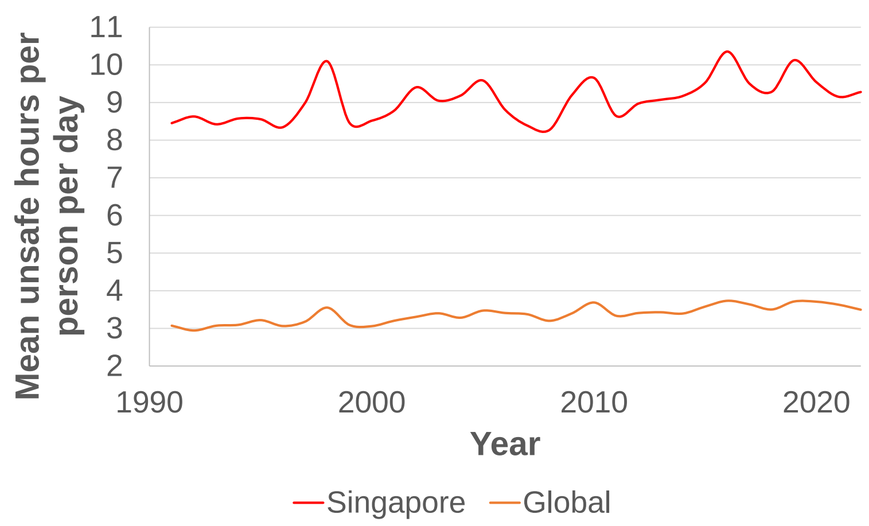

Figure 3 Mean unsafe outdoor exercise hours per person per day from 1991 to 2022, Singapore and globally

Conclusions

Our analysis of trends in outdoor exercise potential revealed **increases** in the number of unsafe exercise hours **both globally and regionally** over the past 30 years **due to climate change**. As reduction of exercise levels on a macro-scale will drastically increase healthcare costs, **interventions and adaptations** to decrease heat stress risk during exercise **are called for**.

This study did not consider the effect of **heat acclimation** in tropical populations (such as Singapore) or in elite athletes, which could allow for **safe exercise beyond currently established thresholds**. As such, future analyses will benefit from population studies eliciting **country-level safe exercise guidelines and risk functions**.

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