been observed in people with stable coronary artery disease, during a short (15 min) and extreme (Finnish sauna, 80°C) heat exposure[69] and whole-body passive heating with increases in core temperature as low as 0.5°C from baseline.[70]

Dehydration

Dehydration and electrolyte imbalances significantly increase the risk of heat-related illnesses, which increases four-fold within just one day following a heatwave.[71] Hypotension can lead to low tissue perfusion which, if persists, leads to multisystemic failure. Essential electrolytes like sodium, potassium or magnesium are crucial for the initiation of transmembrane action potentials. Therefore, electrolyte imbalances which often occur with dehydration can modify action potentials of cardiac myocytes leading to arrhythmias.[72] Additionally, dehydration can activate the sympathetic nervous system (SNS), leading to an increase in heart rate and cardiac metabolic demands of the heart. In patients with pre-existing CVD, this can cause a demand-supply mismatch triggering ischemic events, or plaque ruptures culminating in stroke or myocardial infarction.[73] Loop diuretics, frequently prescribed for heart failure patients, induce a natriuretic effect by inhibiting the sodium-chloride cotransport system in the loop of Henle. Heat exposure exacerbates dehydration and electrolyte imbalances caused by these diuretics. Consequently, episodes of acute heart failure are more frequent during heatwaves.[74] Beta-blocker use may also decrease sweating in the heat,[75] however, a recent meta-analysis has shown that both selective and non-selective beta-blocker use does not impact sweating in the heat, albeit in healthy populations only.[41] Excess sweat losses with heat exposure leads to a reduced plasma volume, impairing the increase in cutaneous vasodilation. A blunted vasodilation leads to an impaired redistribution of internal heat content potentially leading to a higher core temperature. The addition of physical activity also leads to an increase in heart rate, and a decrease in stroke volume compared with euhydration,[76] leading to increased heat strain (*Figure 1*).

The inequitable challenges of heat extremes

Inequitable health challenges such as being on a low income, social isolation, food and water insecurity, poor building infrastructure, lack of urban greening, outdoor work and physical immobility all exacerbate vulnerabilities to the heat. The capacity of our health systems to effectively prepare for and manage increased negative health outcomes will play a significant role in protecting the health of our communities.[77,78]

Reducing vulnerability and improving sustainability must be a requirement embedded within policy, research and stakeholders moving forward. A heavy emphasis of many public health intervention policies to reduce the negative health effects of heat has been the provision of cooling assistance to people in heat-vulnerable households and communities, primarily through broadening access to air conditioning. However, it is not just the capital costs of air conditioning that preclude its use by many of the most vulnerable to the heat. In Australia, two-thirds of a sample of elderly people who own an air conditioning unit reported that they chose not to use it even during extremely hot weather because of high electricity costs.[79] Recent research has demonstrated more cost-effective solutions, such as the deployment of central public cooling centres[80] or personalized cooling strategies (i.e. fan use),[40] which have been shown to reduce heat strain in vulnerable populations; however, research is still limited. Furthermore, while such an approach may prove effective for specific subpopulations, e.g. it is likely that people experiencing homelessness, and many of the most vulnerable to the heat are likely unaware of the existence or location of cooling centres due to social isolation, unable to access them because of a lack of mobility, or a preference to remain at home.

Migration to cooler locations has been a result of global warming[81] and an accelerating cost of living. However, this distinct increase in urbanisation leads to a greater number of vulnerable communities in densely populated and hot regions, increasing the risk of negative heat health outcomes, necessitating another move.[81] Urban green space, such as parks, trees or green roofs, can effectively cool an outdoor space by ∼0.9°C,[82] and can address environmental inequities to make neighbourhoods cooler, reducing the urban heat island effect. Problematically, green spaces are predominantly located in more affluent areas[83] and the inclusion of green spaces in city plans may be overlooked due to lack of funds, particularly in urbanized areas.[84]

Low-to-middle income countries are either seeing no change, or an increase in CVD,[85] which is compounded by a greater number of heat extreme days paralleled by lower annual income, and greater difficulties accessing health facilities—all risk factors for increased morbidity and mortality with heat extremes. In 2023, only 61% of countries that formed the World Health Organisations Alliance for Transformative Action on Climate and Health had completed a vulnerability and adaption assessment. These assessments were mostly carried out in high-income countries, which will inevitably delay the implementation of effective strategies to reduce health inequalities with heat exposure,[84] especially in low-to-middle income countries.

Extreme heat may impact behavioural choices, particularly in the context of primary and secondary prevention. For example, key risk factors for CVD and stroke are a poor diet, physical inactivity, and harmful use of alcohol. However, in the face of global warming, access to food, clean drinking water and medications, and the ability to exercise can be severely restricted.[86] In hot workplaces, even otherwise healthy younger adults can suffer exertional heatstroke,[87] especially if activities require high levels of physical exertion that generate large quantities of metabolic heat, and/or protective clothing is worn that blocks heat dissipation from the skin. Labour working conditions can heighten these heat-related health risks. Durations of heat exposure can be excessive if regulations that limit heat exposure are not followed or non-existent, and/or workers are paid according to productivity and therefore resist self-pacing that would otherwise moderate heat stress. Working environments that do not provide adequate resources for shaded rest and rehydration also increase the risk of heat illness. Problematically, all these challenges are projected to increase, with rising temperatures assured over the coming years.

Research agenda

The health burden of climate change is preventable, yet we lack long-term prevention plans and adaption strategies for people with CVD. There has been limited research guiding evidence-based care and advice to protect people with CVD against heat extremes. Any current generic advice lacks empirical evidence and does not consider clinical factors like age, co-morbidities, or medication.[6,88] Therefore, research is needed to generate knowledge surrounding the physiological factors predisposing people with CVD to heat-related morbidity and mortality, especially outside of the context of heatstroke (Box 2). Furthermore, there is seldom an interdisciplinary approach to address the gaps in cardiovascular care in the face of climate change. Researchers must encapsulate a collaborative approach with the inclusion of physiologists, clinicians, climate scientists, public health, and consumers in their work.