Outdoor Sport in Extreme Heat: Capturing the Personal Experiences of Elite Athletes

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ABSTRACT: Heat stress from the environment can be detrimental to athletes' health and performance. No research, however, has explored how elite athletes conceptualize and experience heatwaves and climate change. Utilizing a qualitative approach, this study examined elite athletes' perceptions, experiences, and responses to extreme heat in relation to climate change and explored the use of their platforms for climate activism. Fourteen elite athletes from the United Kingdom, Australia, the United States, Sweden, and Canada, who represented 10 different sports including race walking, netball, and cricket were recruited using snowball sampling. Data were collected using semistructured interviews. Thematic analysis revealed four broad themes. The first theme reflected uncertainty surrounding the causes of heatwaves and the impact of heat on athlete health and performance. The second theme reflected care and concern for sport and society, including concern for the well-being of athletes and spectators, the impact of heat on facilities and participation at the grassroots level, and how the nature of sport may change in the future. The third theme referred to the implications of heatwave experience on athlete health and performance, and how experience affected individual and organizational preparedness. The fourth theme referred to enablers and barriers to successful climate change communication. This study contributes to the sport ecology literature by introducing the subjective heat experiences of elite athletes. Educating athletes and event organizers about the impacts of heat on sport participation is imperative to increase awareness and, it is hoped, to limit illness for those training and competing.

KEYWORDS: Social science; Heat wave; Climate change

1. Introduction

Climate change is increasing the frequency, intensity, and duration of extreme heat events such as heatwaves worldwide (Dosio et al. 2018). Although there is no single internationally accepted definition of a heatwave, broadly defined, heatwaves are extended periods of abnormally hot weather (IPCC 2018). Heatwaves are a major health hazard to athletes at all levels, especially those who compete in outdoor summer sports such as track and field, cricket, and tennis. A growing body of research has highlighted that individuals exercise best in cool, dry conditions with optimal athletic performances typically around 10°–15°C (50°–59°F) (Oikawa et al. 2021). As environmental temperatures and humidity increase, both cognitive and physical performance deteriorates, to the point where health is negatively implicated. The specific risks associated with extreme heat (i.e., temperatures that are substantially hotter than average) and humidity include heat-related illnesses (e.g., muscle cramping, heat exhaustion, and heat stroke; Mountjoy et al. 2012; Yankelson et al. 2014) and performance deterioration (e.g., slower marathon winning times; Miller-Rushing et al. 2012).

Although fatal heat-related injury during sport is rare, several cases of heat-related illness during elite sport have been documented. In 2018, six tennis athletes were forced to retire from the United States Open because of heat stress and exhaustion, and French tennis star A. Cornet collapsed at the Australian Open as temperatures soared to 42°C. In the same year, triathlete J. Brownlee suffered severe heat exhaustion during the Mexican Commonwealth Games. The following year, medical staff were on call at the 2019 World Athletics Championships in Doha after 28 athletes failed to finish the women's marathon because of the oppressive conditions. Many athletes suffered a similar fate at the Tokyo 2020 Olympics, with 78 cases of exertional heat illnesses recorded (Soligard et al. 2023). Despite these occurrences, outdoor summer sports are generally not suspended even with the presence of extreme heat (Petro 2011). Instead, organizers commonly introduce precautionary measures such as extra drink breaks. Despite the well-known benefits of increased fluid intake to enhance performance while reducing the risk of developing heat illness, heat- and dehydration-related problems persist in sport (Bergeron et al. 2005).

It is clear just from these examples that there are urgent and immediate consequences of extreme heat for elite athletes. This is especially important to recognize in light of the

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latest Intergovernmental Panel on Climate Change (IPCC) report, which warns that every increment of warming will intensify heatwaves across most regions, resulting in further devastating impacts to athlete health and performance (IPCC 2023). However, research into the sport–climate relationship is scarce, which is surprising given its global significance and the evident vulnerability of certain sports (e.g., marathon, tennis, and road cycling) because of their climate-exposed outdoor settings (Orr and Inoue 2019). A few exceptions have focused on the role of ski activism in combatting climate change (e.g., Mihala 2019) and the vulnerability of ski industries (e.g., Scott et al. 2019), but these studies are limited to snow sports with athlete perspectives and climate change receiving little attention (Schneider and Mücke 2023).

2. Literature review

a. Research on sport and climate

The relationship between sport and the natural environment flows in two ways; that is, sport has an impact on the natural environment, while the natural environment impacts sport (McCullough et al. 2020). Over the past few decades, research exploring the relationship between sport and the natural environment has grown considerably and has recently been termed "sport ecology" (McCullough et al. 2020). Most commonly, researchers in sport management have focused on how the sport industry has impacted the natural environment. Examples are largely in the context of the environmental impact of sport (Collins et al. 2007, 2012; Wicker 2018), sport sustainability (Kellison and Hong 2015; Sartore-Baldwin and McCullough 2018), and fan engagement in environmental practices (Casper et al. 2017; McCullough and Cunningham 2011).

While such studies are important, they do not consider the other half of the sport–environment relationship; that is, the effects of climate change on sport. There are, however, a few exceptions. For example, Scott et al. (2022) incorporated perspectives of elite international snow sport athletes and coaches to inform the development of climate indicators and provide new insights into the Olympic competition conditions deemed to be safe and fair. Other research has focused on the climate vulnerability of specific sports, facilities, and organizations (Dingle and Mallen 2020; Dingle and Stewart 2018; Orr 2020; Orr and Inoue 2019). In addition, researchers have investigated climate change risk in the ski industry (Rutty et al. 2017; Scott et al. 2019) and the suitability of cities to host future summer and winter Olympic and Paralympic Games (Ross and Orr 2022; Scott et al. 2019). However, studies of heat impacts and awareness are rare and remain limited to sports tourists (Matzarakis and Fröhlich 2015) and recreational endurance athletes (Shendell et al. 2010). To date, no research has explicitly examined elite athletes' perceptions and experiences of extreme heat or their engagement with climate activism.

While very little research has examined the impacts of climate change on sport, there is a considerable body of research in sport science that demonstrates the physiological effects of heat on athlete health and performance. Researchers have done so through the lenses of health and performance implications (Miller-Rushing et al. 2012; Mohr et al. 2012; Smith et al. 2018) and the efficacy of coping and mitigation strategies such as heat acclimatization (Alhadad et al. 2019; Périard et al. 2021, 2017; Racinais et al. 2015, 2021). Nevertheless, not all athletes have the same risk of being negatively affected by the heat. For example, athletes performing in endurance, racket, or team sports events are at greater risk due to the high intensity and/or long duration of training sessions, races, and/or matches (Mohr et al. 2012; Mountjoy et al. 2012; Racinais et al. 2015; Yankelson et al. 2014). The main factors determining the likelihood of heat-related issues relate to 1) environmental conditions—temperature, humidity, solar load; 2) intensity and duration of exercise; 3) clothing worn; and 4) individual factors—body size, health status, and age (Armstrong et al. 2007). These factors are particularly relevant to sports played outdoors in summer. Cricket, for example, is popular in many hot countries (e.g., Australia, South Africa, and India) and involves a range of exercise from near rest to intense exercise. Cricketers also wear a variety of clothing that can act as a barrier to heat exchange (e.g., padding and head protection). Thus, the risk of developing heat-related issues can vary from day to day and from player to player and is highly dependent on the type of sport, location, and policies in place.

b. Importance of personal experience

Research in psychology suggests that personal experiences of extreme weather events and/or local weather anomalies such as temperature fluctuations can play a key role in shaping climate change risk perceptions through experiential processing (Demski et al. 2017; Marx et al. 2007; Spence et al. 2011; van der Linden 2015; Weber 2006; Zaval et al. 2014). This describes the process whereby negative affective responses to the impacts of extreme weather are attributed to climate change and the salient memories of such impacts heighten perceived risk from climate change (Ogunbode et al. 2019). Behavioral decision research indicates that such experiences provide an opportunity for individuals to witness the otherwise abstract effects of climate change and as such, make the risk more tangible and familiar (Lorenzoni and Pidgeon 2006; Reser et al. 2014; Smith and Joffe 2013; Spence et al. 2011; Weber 2010). Although there is mixed evidence about the capacity for personal experience to shape climate opinions (Howe et al. 2019; Sambrook et al. 2021), extreme weather events have been shown in some cases to increase perceived risk (Brulle et al. 2012; Carlton et al. 2016; Whitmarsh 2008), increase environmental concern, and promote action (Bergquist et al. 2019; Broomell et al. 2017; Demski et al. 2017; Ngo et al. 2020; Spence et al. 2011).

The importance of personal experience is yet to be studied in a sport context. However, as previous research has shown, these experiences are important to incorporate as they may not only play a vital role in athlete preparedness for future heatwave events, but also could be utilized to help bring the

TABLE 1. Participant characteristics.

Participant pseudonym	Age group (yr)	Gender	Location	Sport	Level of competition	Education
Emma	26–34	Female	Australia	Netball	National	Masters
Andrew	26–34	Male	Canada	Race walking	International	Bachelors
Jack	18–25	Male	United Kingdom	Cricket	National	Bachelors
Michael	26–34	Male	United States of America	Baseball	National	Bachelors
Jessica	26–34	Female	United Kingdom	Field Hockey	International	Bachelors
Oscar	26–34	Male	Sweden	Race walking	International	Secondary
Megan	26–34	Female	Australia	Netball	National	Doctorate
Matthew	26–34	Male	United Kingdom	Golf	International	Secondary
Sarah	26–34	Female	United Kingdom	Rowing	International	Bachelors
Hannah	18–25	Female	United States of America	Rugby sevens	International	Bachelors
Luke	26–34	Male	Australia	Race walking	International	Bachelors
David	35–44	Male	United Kingdom	Canoe slalom	International	Bachelors
Harry	18–25	Male	United Kingdom	Race walking	International	Bachelors
Daniel	26–34	Male	Australia	Australian rules football	National	Masters

issue of climate change to the fore (Demski et al. 2017; Zaval et al. 2014; Spence et al. 2011). With its global reach, the sport industry has a unique power to capture the attention of and unify a worldwide audience on the issue of climate change, a power that most sectors cannot equal (Orr et al. 2020). Therefore, elite athletes have a powerful opportunity to communicate the urgent need for climate action.

3. Present study and research questions

As climate change continues to impact sport, a crucial viewpoint missing from the limited research is that of the athletes themselves. The research questions were therefore motivated by the gaps identified in previous research in sport science/sport management and by theories in psychology and behavioral decision research, which aim to account for the links between personal experience and climate change risk perceptions. Specifically, personal experience is thought to influence risk perception through its ability to reduce perceived psychological distance of climate change along three dimensions—temporally, socially, and geographically (McDonald et al. 2015). Additionally, experiences with extreme weather events may also elicit negative affective responses, which can heighten risk perceptions (Keller et al. 2006).

Therefore, the aim of this study was to understand elite athletes' perceptions of, experiences with, and responses to extreme heat in relation to climate change and explore the use of their platforms for climate activism. Our research questions were 1) What is the current knowledge and awareness of the causes and risks of heatwaves among elite athletes? 2) How has extreme heat affected athlete health and performance? 3) How do athletes and organizers prepare and respond to heat waves? and 4) Why do elite athletes choose to engage in climate activism or choose not to?

To address these research questions, we conducted semi-structured interviews with elite athletes from the United Kingdom, Australia, the United States, Sweden, and Canada and explored how they conceptualized and discussed heatwaves and climate change, as well as the implications of experience on health and performance.

4. Method

a. Research design

A qualitative phenomenological research design was used, which provided a unique opportunity to capture the in-depth perspectives and lived experiences of participants (Swanson and Holton 2005). Specifically, semistructured interviews were used to gain an understanding of the meanings each participant attributed to their experiences while providing the interviewer with the opportunity to probe emergent responses and themes (Saunders and Townsend 2016). The study and interview materials were granted ethical approval by the Research Ethics Committee of the University of Leeds (LTSEE-122), and all research was conducted in accordance with the Declaration of Helsinki.

b. Participants

Fourteen participants from a range of countries and sports took part in the study. Brief descriptions of the sports in which they are involved are reported in the online supplemental material (Table S1). Each participant was assigned a pseudonym to maintain confidentiality. Most participants competed at a national level and/or represented their country at major international competitions such as the Olympic Games. Among the 14 interviewees, there were nine males and five females, aged between 20 and 41 yr (mean = 28.7 yr) and most had a university degree. Data collection was ended when no new themes were arising from the data, suggesting thematic saturation had been reached (Bowen 2008; Saunders et al. 2018). Table 1 summarizes participant characteristics. Additional participant characteristics are reported in the online supplemental material (Table S2).

c. Procedure

Participants were recruited through snowball sampling, which allowed the approaching of elite athletes who may otherwise be hard to reach (Waters 2015). The call for participation was shared via email to the lead author's existing sport network and via online social media channels (e.g., Twitter and LinkedIn). Participants were eligible for the research if

TABLE 2. Qualitative themes and subthemes.

Theme	Subthemes
Uncertainty	Causes of heatwaves; risks of heatwaves
Care and concern for sport and society	Human health; grassroots-level sport; future change to the nature of sport
Implications of heatwave experience	Impact on performance and health; impact on individual and organizational preparedness; recommendations to improve preparedness and mitigate impact on health
Climate change communication	Enablers; barriers

they reported having trained and/or competed in extreme heat conditions and were an active and/or retired competitive elite athlete. Seventeen athletes were approached, and 14 athletes ultimately participated. For the purposes of this research, elite athletes were defined as athletes competing at an international and/or a national level (Swann et al. 2015).

Before the interview, participants gave written consent to participate and for the interview to be audio recorded. All interviews were conducted online in English by the lead author between 31 August 2020 and 2 June 2021. Each interview lasted between 30 and 60 min (average = 50 min). All interviews were audio recorded and transcribed verbatim. The interview schedule focused on five key topics: 1) knowledge and awareness of heatwaves, 2) attitudes and risk perceptions, 3) personal experience and behavioral responses, 4) effectiveness of heat preparation and policies, and 5) climate change activism. To obtain quality data, the lead author used various interview techniques such as careful phrasing of questions, avoiding leading language, and using follow-up questions (DeJonckheere and Vaughn 2019; Flick 2018).

d. *Data analysis*

The lead author conducted data analysis, with feedback provided through regular discussions with the coauthors to ensure credibility. Demographic information was recorded at the beginning of each interview to describe the sample in its entirety. A combined technique of inductive and deductive thematic analysis was conducted using NVivo 12, which is defined as a qualitative approach, independent of quantifiable frequency measures, used for identifying, analyzing, and interpreting patterns within a dataset (Braun and Clarke 2006; Vaismoradi et al. 2013). The analysis was guided by Braun and Clarke's (2006) established six-phase approach. The first phase—data familiarization—was achieved during transcription and reading of the transcripts. In the second phase, we produced initial codes from the data, and in the third phase, the codes were grouped together to form potential themes. In the fourth phase, the identified themes were then reviewed and refined by 1) comparing them with the data extracts to ensure they formed a consistent pattern and 2) rereading the entire dataset to ascertain whether the themes were representative of the data as a whole. In the fifth phase, each theme and subtheme was defined and named. The sixth phase involved writing up the article.

5. Results

We identified four broad themes and within each, several subthemes emerged (see Table 2). The first theme reflected uncertainty surrounding the causes of heatwaves and the impact of heat on athlete health and performance. The second theme reflected care and concern for sport and society, including concern related to the well-being of athletes and spectators, the impact of heat on facilities and participation at the grassroots level, as well as possible changes to the nature of sport in the future. The third theme referred to the implications of heatwave experience on athlete health and performance, as well as how experience affected individual and organizational preparedness. The fourth theme reflected factors that affected the ability of participants to communicate climate change issues to a range of diverse audiences, as well as the enablers and barriers.

a. *Uncertainty*

1) CAUSES OF HEATWAVES

Most participants expressed a great deal of uncertainty about how any of the human and/or natural factors specifically influenced heatwaves, as well as how to define such extreme weather events. Several participants highlighted human-induced climate change as a significant factor in increasing the frequency, intensity, duration, and spatial coverage of heatwaves: "I think over the long term, climate change plays a big, big role in it. But yeah, short term. I don't understand. I don't pretend to grasp how weather works" (Luke, 29, male, race walker). However, a few participants were skeptical of the direct causality between climate change and heatwaves and instead referred to natural processes such as El Niño and high pressure systems trapping hot air as contributing factors:

> I don't necessarily think that they're [heat waves] caused by climate change. I think that climate change is an impacting factor. To be honest, I don't know how they're caused. My assumption is that it's some sort of weather phenomenon. But I couldn't be specific as to exactly what causes it (Daniel, 30, male, Australian Rules football).

2) RISKS OF HEATWAVES

Throughout the interviews, it was clear that there was no consistent dissemination of heatwave risk information from coaches, physiologists, or sport organizations. As a result, the knowledge and awareness of the impacts of heat on athlete health and performance varied significantly between participants, with some receiving no information at all. Those competing in long-distance events such as race walking appeared to receive more information about the risks associated with heat (i.e., severe dehydration and heatstroke) than did those who were competing in less intense sports such as golf. However, participants competing in endurance team sports, which

equally require performances to be sustained at a high level for extended periods of time (i.e., rugby sevens, baseball, and Australian Rules football) reported receiving little information. Having access to the latest research (i.e., on precooling strategies) and resources (i.e., heat chambers) was also important, with participants stating the importance of being among a team who are extremely knowledgeable and can help them prepare for and cope with the heat: "I have some good connections in the field working on heat strategies or cooling strategies in the heat. So, I do chat regularly with coaches, Ph.D. students and professionals in the area" (Oscar, 30, male, race walker). Additionally, athletes performing at national levels reported receiving significantly less (if any) guidance and information than those competing on the international stage: "Not well informed at all. We haven't really had the science behind heat training or the exposure to heatwaves explained to us in any way on any level" (Daniel, 30, male, Australian Rules Football).

b. Care and concern for sport and society

1) HUMAN HEALTH

Most participants who expressed their concern about the impact of heatwaves and climate change on sport and society described similar motivations that tended to underpin these concerns. The first motivation, human health (i.e., athletes and spectators), was most prominent in driving concern and discussion about heatwaves and climate change. Participants frequently used emotive words like "scared," "alarmed," "angry," "sad," and "anxious" to describe the impact of heat on athlete and spectator health and were extremely concerned about the ability of sport organizations to adapt and ultimately provide the best-quality heat protection for individuals: "If heatwaves were to happen more often, I'd be concerned and probably alarmed about the ability of sport organizations to cope with that and be able to adapt their play in a way that kept players safe" (Emma, 31, female, netball).

2) GRASSROOTS-LEVEL SPORT

The second core motivation that underpinned elite athletes' concern about heatwaves and climate change was the potential impact on grassroots-level sport. More specifically, these participants were concerned about the future resilience of local clubs and facilities and the effect of heat on participation and access to outdoor sports in the future: "If places are getting hotter, and they're getting drier, it will limit who can participate" (Jessica, 27, female, hockey).

3) FUTURE CHANGE TO THE NATURE OF SPORT

Alterations to the nature of sport was also a motivator, and many participants referred to how the heat may affect how some sports are played, such as cricket becoming dominated by batsmen, golf becoming a buggy sport, and in athletics, endurance races particularly becoming a lot slower, for example, "I'll forever be the slowest 50k World Championship medalist" (Andrew, 30, male, race walker). In conjunction with the possible increase in schedule changes and rest breaks, shorter matches, canceled competitions, or even sports moving indoors, many participants were worried about the future attractiveness of outdoor sports to athletes at all levels as well as spectators.

c. Implications of heatwave experience

1) IMPACT ON ATHLETE HEALTH AND PERFORMANCE

The majority of the participants said their mental as well as physical performance was negatively impacted when they had trained and competed in extreme heat and humid conditions. Optimal physical performance was difficult to maintain, with most participants recalling feeling dehydrated, weak, dizzy, and exhausted, resulting in slower matches/races and in some cases leading to withdrawal due to severe fatigue:

> I just hit the wall. I was feeling lethargic, dehydrated, I couldn't sleep well. At the race I think it was 27°C. It was a 5pm race. And I pulled out after 7 kilometres out of 10 kilometres because I was wasted. I was dead (Oscar, 30, male, race walker).

These participants also noticed a deterioration in their cognitive performance, with most noting an inability to focus, communicate, and make good tactical decisions, resulting in a higher frequency of errors. From a health perspective, Emma had been left with permanent damage after suffering from heatstroke during a preseason netball tournament in Australia. As a result of the damage incurred, Emma was forced to retire from sport and now struggles with day-to-day life especially on hot days: "Since that day, I have not been able to play sport again. . . . If it's a hot day, and I go outside, I just lose energy so quick, I just can't really do anything" (Emma, 31, female, netball).

However, participants' experience of extreme heat during competition or while training was not always negative. Having a comprehensive heat stress prevention strategy (i.e., training in the heat, precooling, and monitoring fluid consumption) in place made a real difference and ultimately reduced physiological strain and optimized both the physical and mental performance of some participants:

> With Doha and actually competing in the heat, it was so much fun. The biggest competitor wasn't any of the other athletes it was the heat and I was confident that I was going to be able to beat the heat (Andrew, 30, male, race walker).

For these participants, the heat completely changed what was important in their sport. Having complete trust and confidence in both their preparation regime as well as coping strategies significantly minimized the impact of the environment on their racing capabilities.

2) IMPACT ON INDIVIDUAL AND ORGANIZATIONAL PREPAREDNESS

Personal experience of impaired performance and/or a previous diagnosis of exertional heat illness was noted as an important factor that motivated some participants to learn about how to mitigate the effects of extreme heat on health and performance:

> At the time, I didn't have that much experience . . . I remember the race getting much harder, much earlier than normal. And the times were a bit slower as well. And then, when I cracked, I really cracked I didn't just fall off pace, but I really fell off pace . . . Whereas now I'm training for the Tokyo Olympics and from that previous experience I know that I will have to have an extended heat preparation coming up to the event so that I'm heat adapted and can perform well in the heat (Oscar, 30, male, race walker).

The importance of learning from experience was clear but with this in mind, participants also expressed their concern for younger athletes and, despite their high level of fitness, reflected on their own negative experiences at the beginning of their careers, when they had no experience of performing in the heat and knew very little about preparation and coping strategies:

> At that point I was 21, so I was a bit young and hadn't really thought about how to prepare for a hot weather race. I wasn't really prepared for it, in terms of having many interventions or differing strategies (Luke, 29, male, race walker).

The lack of experience in hot conditions was a major fear for one participant, who expressed concern about not knowing the signs of or treatments for heat illness: "What worries me is I don't know what they [heat illnesses] feel like. I don't know anything. I don't know if it's starting to happen or if I'm pushing myself too hard" (Hannah, 25, female, rugby sevens).

However, simply gaining valuable knowledge and experience of one hot environment did not necessarily equate to some participants being mentally and/or physically prepared for their next competition in similar conditions:

> Racing in hot conditions is something that I'm at least quite familiar with, I mean even Rio was 28°–29°C. But Doha was a different animal. We knew it was going to be hot, but I never understood what that meant until we stepped out of the airport. It was way worse than we'd ever imagined (Andrew, 30, male, race walker).

Some participants noted that the same temperature felt different from location to location, and sometimes they experience that performing in the heat resulted in a false sense of security.

With a distinct lack of experience and team support, some participants relied on the organizers for guidance on how to prepare for and how to cope in the heat:

> I just kind of trusted that the authorities in place would have everything under control, like I just never really felt that they would do anything that would put us at risk. So, if we're playing it's because it's safe to do so (Emma, 31, female, netball).

However, the organizational response and the safety measures that were introduced seemed to be dependent on the level of competition. Those participants who had competed at The World Athletics Championships in Doha, for example, referred to an abundance of measures put in place to ensure athletes could cool down properly, for example, multiple drinks stations with ice cold water, ice towels, ice baths, ice jackets, shaded areas, and trained medical professionals on standby in case of emergency. However, this was not always the case at other competitions on the international stage, where it was the responsibility of the individual, the team, and/or the sport governing body to supply athletes with cooling equipment and garments. Harry spoke of the inequality between athletes that resulted from not having access to the same knowledge and resources of a larger team. In contrast, participants reported a sheer lack of safety measures at lower levels of competition (i.e., regional and national), with several participants recalling having access to just one or two cooling methods, for example, cold towels and water.

Interestingly, the level of individual and organizational preparedness was sometimes dependent on whether the hot conditions were expected. Emma and Luke referred to events where the conditions were abnormally hot for the time of year and the location, which resulted in athletes, coaches, and the organizers being less prepared, meaning fewer coping strategies were put in place to protect the health and well-being of athletes and spectators:

> Shepperton because it's not traditionally a hot place, I don't think anyone was going into it thinking, this is going to be a really hot event, let's acclimatize. None of the protocol was in place. There weren't any ice vests or any of that kind of technology or even frozen bottles. It was pretty scaled back compared to what I have seen deployed on different events, when people know that it's going to be hot (Emma, 31, female, netball).

3) Recommendations to improve preparedness and mitigate impact on health

Many participants also suggested measures for organizers and governing bodies to put in place to mitigate against heat illnesses among athletes, coaches, event staff, and spectators. A summary is provided in Table 3.

d. Climate change communication

Most participants used their platforms, albeit at varying degrees, to talk about the issue of climate change. Platforms included social media channels such as Twitter or Instagram, key sport events, and climate action groups such as EcoAthletes. Participants identified a range of environmental and individual factors that affected their ability to communicate climate change issues to a range of diverse audiences. These were categorized into five overarching enablers and six overarching barriers to successful climate change communication. Table 4 summarizes each factor.

1) Enablers

Education was considered crucial by most participants to not only build knowledge, awareness, responsibility, and behavioral intention regarding climate change, but also to empower them to speak about the issue with passion and confidence to their sport communities. Through reading and learning, participants understood climate change to be a serious threat to themselves, their families, and their sport, while a few also alluded to the crisis exacerbating other issues such as global inequality:

> I think it's the greatest threat to humanity. And there are lots of other issues that I care about, like equality and poverty and racial justice and the justice system in general but all of these are, I feel hinge on us having a healthy environment to live in and on (Sarah, 27, female, rowing).

TABLE 3. The key heat recommendations suggested by participants.

Education strategies focused on the risks of heat to athletic performance and health, as well as information regarding adequate nutrition and hydration practices
Early warning system (understandable to a lay person) that notifies organizers to follow a heat protocol for their event, which allows for proper preparation to be put into place
Athlete health to be put at the heart of sport organizations' agendas
Scheduling events at cooler times of the day (i.e., morning or evening), which is safer for athletes, rather than selecting a time that will have the largest television audience
Organizers to set up cooling facilities such as ice baths for before and after events, allowing athletes who do not have access to the resources of a bigger team to utilize the intervention
Before events occur, organizers should reach out to the athletes and teams about preparation strategies to ensure that everyone is knowledgeable and well equipped for the hot conditions
Sport organizations and/or federations to release guidelines for sport at all levels on how to organize events during hot weather conditions
Organizers to document the occurrence of heat-related illness during events to gain an understanding of incidence rates
Organizers to provide ice-cold water and shade wherever possible
Sport organizations and/or federations to create a healthy environment for athletes to speak about their experiences performing in extreme weather as well as their relation to climate change, without fear of judgment
All sport-governing bodies to develop science-based heat policies to protect athletes and spectators from the risks of extreme heat

The second factor enabling some participants to communicate the climate change issue with ease was having a real story to tell that people could relate to. Emma spoke of her own heatwave experience, and even though it forced them to retire from their sport, it also offered a more personal, powerful, and meaningful way to connect and engage with others on the topic of climate change: "It's a real story that other people can connect to. I think for me, it makes it a bit easier, because I can just be real and speak on my own experience" (Emma, 31, female, netball). Using a narrative form of communication became a window into their world, which was key to starting a conversation about climate change and ultimately creating the space for other people to follow with their own experiences. Additionally, other participants often mentioned the power of the athlete voice as an equally important tool to raise awareness of the climate crisis and potentially encourage their followers to take action: "I believe that sport can be a vehicle for change, and that athletes have the power to give voice to organizations or individuals who otherwise would not be heard" (Daniel, 30, male, Australian Rules Football). The source of their power to inspire and affect change was described as a result of the attributes they convey such as resilience, ambition, innovation, leadership, and self-sacrifice, which draw admiration from fans. However, a few participants struggled to find the right way to use their voice and disagreed about the extent to which their voice could be a catalyst of change: "I just don't think I am a person that is going to sway anyone's decision-making on the topic, and therefore, speaking about it tends to feel very performative" (Andrew, 30, male, race walker).

The importance of caring for the environment and protecting future generations was also frequently discussed. Several participants referred to their own experiences of being able to explore their full potential as athletes and being able to develop, grow, and learn in a healthy environment. These participants were therefore motivated to use their powerful voices to speak about climate change to ensure that children of present and future generations were granted the same experiences and opportunities, especially in sport:

> I want good things for people, because of the experiences I've had. I want people to enjoy the power of sport, I want people to enjoy my sport in the future. But none of those things are going to happen if we continue what we're doing (David, 41, male, canoe slalom).

2) BARRIERS

Although education was referred to as a powerful enabler that empowered participants to speak about climate change, it was also viewed as one of the main internal barriers. A lack of knowledge and understanding of the physical climate science, as well as how to communicate the issue effectively, impeded, and in some cases prevented, several participants from speaking about climate change:

> It's just something that is a bit beyond my depth. I understand things at a very basic level but certainly not enough to engage in meaningful discussions online with people who have a differing opinion (Andrew, 30, male, race walker).

These participants frequently spoke of the need to "be perfect to speak out," and if this was not the case, they feared

TABLE 4. Enablers and barriers to climate change communication.

Category	Factors
Enablers	Education; having a real story to tell; power of the athlete voice; care for the environment and future generations; sense of duty and responsibility
Barriers	Knowledge and education; fear of judgment; no plan B; climate change skepticism; small platform; distraction from other issues

public ridicule and scrutiny not only for speaking about a topic that they did not completely understand, but also for being accused of hypocrisy for their high-carbon lifestyles. By using their platform to speak about climate change, other participants feared being in the spotlight, especially if they were underperforming in their sport: "It's hard to be that guy that's trying to send out a different message when you know, it's easy for a fan to go back and say, focus on your cricket, you're not doing very well at the moment" (Jack, 23, male, cricket). Similarly, Emma and Megan spoke of teammates who were defined by their sport and ultimately had "*no plan B*" and therefore were afraid to express their feelings about climate change through fear of jeopardizing their careers or losing funding: "Netball is a sport that struggles to get funding, sponsors, and even coverage. So, no one will want to put that at risk not just for themselves, but for everyone else that's playing" (Emma, 31, female, netball).

Although most participants were keen to openly discuss climate change, Matthew and Harry were extremely skeptical about its existence, explaining how "there's not enough scientific evidence it's happening" (Matthew, 31, male, golf). Both participants stated a need for more scientific evidence and a greater number of high-profile athletes engaging in climate change advocacy to encourage others who have not spoken out about climate change. Given their small platforms, some participants were also skeptical of their individual ability to be heard and ultimately encourage action, with many identifying the need for governing bodies to step up and safeguard the future of sport: "My individual ability to influence this is limited, because we need system-level changes" (David, 41, male, canoe slalom). However, one participant feared being heard as it may distract attention from other issues such as racial justice:

> In America, a lot of athletes are rightfully bringing attention to like the Black Lives Matter movement. And so, I guess it can feel like as an athlete, if I'm complaining about climate change am I distracting from them or taking away their time? (Luke, 29, male, race walker).

6. Discussion

The Intergovernmental Panel on Climate Change has published several comprehensive reports highlighting the state of the current climate and its impacts and how these changes will interact with human and environmental health in the future. The latest report indicates that global surface temperature was 1.09°C higher in the period 2011–20 than in the period 1850–1900, increasing the frequency and intensity of heatwaves across most land regions (IPCC 2021). Exercising under such extreme environmental conditions will increase the likelihood of developing exertional heat illness, affecting athletes' coordination (Muniz-Pardos et al. 2019), reducing cognitive function (Lieberman et al. 2005), impairing performance (Nybo et al. 2014), and in some cases, leading to heatstroke and collapse (Kenefick and Sawka 2007). Despite this, in the current study, we found that the knowledge and awareness of the impacts of heat on athlete health and performance varied significantly and appeared to be associated with sport type, access to research and resources, athlete level, and personal experience.

Our findings provide a unique understanding of how elite athletes conceptualize and discuss heatwaves and climate change, as well as the implications of experience on their health, performance, and sport in general. Specifically, our findings highlight how elite athletes are often uncertain about the cause, impacts, and urgency to address heatwaves and climate change. We found a clear division in knowledge and awareness of the risks of heatwaves, which seemed to be related to sport type, access to the latest research, athlete level, and personal experience of impaired health and performance. These factors, along with the expectation of abnormally hot temperatures, were often related to the level of individual and organizational preparedness. Despite the uncertainty and distinct divide in knowledge, our results indicate that athletes are generally aware that heatwaves and climate change create an ongoing struggle for sport and future generations, with concerns that further warming will negatively impact human health, grassroots-level sport, and participation. With this in mind, the majority of athletes were motivated to use their platforms (albeit to varying degrees) to talk about the issue of climate change and identified a range of enablers and barriers that affected their ability to communicate climate change issues to a range of diverse audiences.

To the best of our knowledge, this is the first study to explore how elite athletes conceptualize and experience heatwaves and climate change. In contrast, previous research on climate opinion has predominantly focused on the effect of local weather anomalies and extreme weather on climate change beliefs among the general public, often using a quantitative approach. The current qualitative interview-based approach focusing on elite athletes makes an important contribution to the sport ecology literature by introducing the subjective heat experiences of athletes. Previous work has focused on the physiological effects of heat on athlete responses and performance (Donnelly et al. 2016; Mohr et al. 2012), but our results demonstrate the necessity of a qualitative research approach to fully understand the rich and multifaceted experiences of extreme heat and climate change. With a distinct focus on elite athletes and extreme heat, this research provides an in-depth understanding of the ideology surrounding climate change across sport communities and extends the literature on personal experience and climate opinion (Akerlof et al. 2013; Bergquist et al. 2019; Demski et al. 2017; Spence et al. 2011; Whitmarsh 2008).

The impact of heat on sport performance is closely linked to the duration of the event, with a larger decrease in performance during endurance events (Bouscaren et al. 2019). Such events are often described as compromised by the heat (Guy et al. 2014; Taylor 2000), and athletes taking part in long-distance events can be at risk of substantial dehydration and overheating (González-Alonso et al. 1999). This may explain why such athletes were often knowledgeable and aware of the risks of heat to their health and performance. Athletes competing at international levels also reported receiving guidance on heatwave risk, whereas those competing at national levels

often reported receiving little guidance. International sport competitions are increasingly being held in hot and/or humid cities such as the 2019 World Athletics Championships in Doha and the 2020 Olympic Games in Tokyo. Therefore, in recent years, nations and governing bodies have committed more time, research, and resources to enable athletes to cope with the challenging conditions and to develop effective strategies that can be applied during the competition to optimize performance and reduce the risk of heat-related illness (Griggs et al. 2020). Nevertheless, our research indicates that the negative effects of heat are widespread and may not be exclusive to a specific sport discipline or athletes of a particular age or fitness level. This is consistent with previous research showing that the risk of developing exertional heat illness is also elevated in shorter races and field events (Périard et al. 2017) as well as team sports such as football (Mountjoy et al. 2012; Racinais et al. 2012).

Personal experience of heat illness and/or impaired performance often motivated participants to improve their knowledge and understanding of how to prepare for and perform well in hot environments. The impact of high temperatures and humidity on performance and the risk of heat-related illness can vary significantly from person to person contingent on a wide range of chronic and acute individual factors such as body size, degree of acclimatization, hydration status, and heat production (Armstrong et al. 2007). Therefore, the most effective coping strategies that meet the needs of each individual are typically only learned by repeated exposure to the heat and trial and error (Maughan and Shirreffs 2004). These findings are in line with a previous cohort study examining the strategies and factors associated with preparedness for competing in the hot and humid conditions at the 2015 World Athletics Championships in Beijing (Périard et al. 2017). The results indicated that the adoption of a combined heat stress prevention strategy (e.g., acclimatization, precooling, and hydration) strongly depended on a previous diagnosis of exertional heat illness and on the sex of the athlete. However, specific heat stress prevention strategies such as heat acclimatization prior to the championships were uncommon even among athletes with previous experience of exertional health illness symptoms. Accordingly, a better understanding of the factors that influence the preparation and adoption of specific coping strategies is clearly warranted.

Despite the importance of learning from experience, our research also indicates that not all athletes have sufficient experience of hot and humid conditions to fully understand how they will respond to heat stress and accordingly develop their own coping strategies. Without proper knowledge and experience, younger athletes may not realize the early signs and symptoms of exertional heat illness and as a result, continue competing. This "warrior mentality" or internal motivation to push oneself could further increase the risk of exertional heat illness in athletes who have not prepared adequately (Hosokawa et al. 2014). Risk factors for exertional heat-related illness may be internal or external, including younger age and poor education about exertional heat-related illness and prevention strategies (Nichols 2014). These individual risk factors, among others, will likely only worsen the burden of thermally stressful environmental conditions with unequal consequences, highlighting how excessive heat may exacerbate inequality among athletes at all levels. Therefore, it is imperative that all athletes, regardless of sport type, level, and experience, receive information and guidance on various preparation strategies ahead of a competition expected to take place in hot and/or humid conditions.

Given the expected increase in heatwaves, many participants expressed their concern about climate change by referring to emotions such as "scared," "alarmed," "angry," "sad," and "anxious." Negative emotional responses toward climate change can play an important role in driving climate change perceptions and actions (Brosch 2021). The high presence of emotional responses was coupled with a concern for human health and youth participation, the ability of grassroots-level sport to maintain facilities, and the future of sport as we know it. This aligns with findings from the quantitative literature indicating that "objects of care" such as future generations and the environment can motivate caring about climate change (Wang et al. 2018). Accordingly, future research might explore how emotions influence the decisions and actions of athletes on climate change. In the absence of sufficient rest, hydration, nourishment, acclimatization, etc., the ability of younger athletes to tolerate hot environments is significantly reduced, and consequently, the risk of developing exertional heat illness is elevated (Bergeron 2015). Previous research conducted in the United States has shown that the diagnosis of exertional heat illness has increased in young athletes and is the leading cause of death at youth-level sport, with the majority associated with football (Maron et al. 2009). Every individual is different, and the ability to adapt to the heat will vary, which may have implications for team selection, for example. Accordingly, extreme heat could present significant challenges to youth participation and equality at present and in the future, especially if sport shifts from one of athletic skill to one of heat endurance.

For climate change communication, our research detected a small but growing pool of elite athletes who have been outspoken on environmental and climate issues. Several factors that enabled climate change communication were identified, with knowledge and awareness of climate change being considered the most important. This is in line with previous research that has shown that knowledge of climate change consequences and concern about the future of lifestyle sports such as skiing and snowboarding can motivate activist behavior (Mihala 2019). However, participants also raised concerns about and barriers to using their platform to speak about climate change. Considering all this and given the power of narrative forms of communication, it may be useful to amplify athletes' stories to show that people may, in fact, be successfully involved in sport, strongly identify with the athlete role, and communicate the issue of climate change. Accordingly, this could create spaces for athletes who may be intending to engage in climate change to discuss their apprehensions in safe environments where there is minimal risk of being judged. It may also provide opportunities to discuss concerns about engaging in climate change discussions, such as losing support from sponsors.

The diversity of barriers identified indicates a need for a comprehensive strategy to foster engagement among athletes.

Basic information provision to overcome lack of knowledge about climate change, highlighting implications for athletes and sport is critical to empower individuals to speak out. With these obstacles in mind, several sports-focused climate organizations have already been established, such as EcoAthletes, which identifies, coaches, and deploys athletes to talk about climate change. By equipping athletes with appropriate knowledge and skills, it is hoped that more will be encouraged to overcome the identified barriers and use their platforms to lead on climate change action.

7. Limitations and future research

As with any research, ours is not without limitations. Our interviews enabled us to gain an in-depth perspective of elite athletes' experience of heatwaves, but the results should be interpreted with caution given the small sample, the snowballing approach, and the absence of multiple coders, which could reduce reliability. Future research involving larger samples could examine how perceptions and experiences of extreme heat and climate change may differ between sports, gender, level of competition, and nationality. Future work could also involve athletes from Asia, Central and South America, and Africa, as well as athletes who practice other outdoor sports such as tennis, triathlon, and football. In addition, given the potential power of the sport community to inspire and accelerate climate action, future work should continue to assess the role of elite athletes in communicating climate change. As a result of existing quantitative studies having a distinct focus on public experiences of flooding (Sambrook et al. 2021), this study was purposefully confined to elite athletes and extreme heat. Future work could examine perceptions and experiences of other climate impacts such as hurricanes and droughts among the wider sport community, which remain poorly understood.

8. Conclusions

This exploratory study of extreme heat and outdoor sport has provided a unique insight into the perspectives and experiences of elite athletes. As sport organizations address the impact of climate change, it is important that athletes, coaches, and event organizers receive more education about the impacts of heat on sport participation to increase knowledge and awareness and, it is hoped, to limit illness for those training and competing. In addition, as more athletes use their popularity to shed light on climate change, it is hoped that this study will inform sport organizations on how they can support and empower athletes to communicate the issue. The findings speak to the importance of a sport narrative around extreme heat that includes climate change. Using sport to communicate about the risks of extreme heat and other extreme weather events may provide a powerful narrative about climate change impacts for engaging fans and wider audiences about rising climate risks.

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Data availability statement. The anonymized transcripts that support the findings of this study are available on request from corresponding author Sambrook. The full interview guide used in the study can be found in the online supplemental material (Table S3).

REFERENCES

Akerlof, K., E. W. Maibach, D. Fitzgerald, A. Y. Cedeno, and A. Neuman, 2013: Do people "personally experience" global warming, and if so how, and does it matter? *Global Environ. Change*, **23**, 81–91, https://doi.org/10.1016/j.gloenvcha.2012.07.006.

Alhadad, S. B., P. M. S. Tan, and J. K. W. Lee, 2019: Efficacy of heat mitigation strategies on core temperature and endurance exercise: A meta-analysis. *Front. Physiol.*, **10**, 71, https://doi.org/10.3389/fphys.2019.00071.

Armstrong, L. E., D. J. Casa, M. Millard-Stafford, D. S. Moran, S. W. Pyne, and W. O. Roberts, 2007: Exertional heat illness during training and competition. *Med. Sci. Sports Exercise*, **39**, 556–572, https://doi.org/10.1249/MSS.0b013e31802fa199.

Bergeron, M. F., 2015: Training and competing in the heat in youth sports: No sweat? *Br. J. Sports Med.*, **49**, 837–839, https://doi.org/10.1136/bjsports-2015-094662.

——, and Coauthors, 2005: Youth football: Heat stress and injury risk. *Med. Sci. Sports Exercise*, **37**, 1421–1430, https://doi.org/10.1249/01.mss.0000174891.46893.82.

Bergquist, M., A. Nilsson, and P. W. Schultz, 2019: Experiencing a severe weather event increases concern about climate change. *Front. Psychol.*, **10**, 220, https://doi.org/10.3389/fpsyg.2019.00220.

Bouscaren, N., G. Y. Millet, and S. Racinais, 2019: Heat stress challenges in marathon vs. ultra-endurance running. *Front. Sports Active Living*, **1**, 59, https://doi.org/10.3389/fspor.2019.00059.

Bowen, G. A., 2008: Naturalistic inquiry and the saturation concept: A research note. *Qual. Res.*, **8**, 137–152, https://doi.org/10.1177/1468794107085301.

Braun, V., and V. Clarke, 2006: Using thematic analysis in psychology. *Qual. Res. Psychol.*, **3**, 77–101, https://doi.org/10.1191/1478088706qp063oa.

Broomell, S. B., J.-F. Winkles, and P. B. Kane, 2017: The perception of daily temperatures as evidence of global warming. *Wea. Climate Soc.*, **9**, 563–574, https://doi.org/10.1175/WCAS-D-17-0003.1.

Brosch, T., 2021: Affect and emotions as drivers of climate change perception and action: A review. *Curr. Opin. Behav. Sci.*, **42**, 15–21, https://doi.org/10.1016/j.cobeha.2021.02.001.

Brulle, R. J., J. Carmichael, and J. C. Jenkins, 2012: Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. *Climatic Change*, **114**, 169–188, https://doi.org/10.1007/s10584-012-0403-y.

Carlton, J. S., A. S. Mase, C. L. Knutson, M. C. Lemos, T. Haigh, D. P. Todey, and L. S. Prokopy, 2016: The effects of extreme drought on climate change beliefs, risk perceptions, and adaptation attitudes. *Climatic Change*, **135**, 211–226, https://doi.org/10.1007/s10584-015-1561-5.

Casper, J. M., M. E. Pfahl, and B. P. McCullough, 2017: Is going green worth it? Assessing fan engagement and perceptions of athletic department environmental efforts. *J.*

Appl. Sport Manage., **9**, 11, https://doi.org/10.18666/JASM-2017-V9-I1-7690.

Collins, A., A. Flynn, M. Munday, and A. Roberts, 2007: Assessing the environmental consequences of major sporting events: The 2003/04 FA Cup Final. *Urban Stud.*, **44**, 457–476, https://doi.org/10.1080/00420980601131878.

——, M. Munday, and A. Roberts, 2012: Environmental consequences of tourism consumption at major events: An analysis of the UK stages of the 2007 Tour de France. *J. Travel Res.*, **51**, 577–590, https://doi.org/10.1177/0047287511434113.

DeJonckheere, M., and L. M. Vaughn, 2019: Semistructured interviewing in primary care research: A balance of relationship and rigour. *Fam. Med. Community Health*, **7**, e000057, https://doi.org/10.1136/fmch-2018-000057.

Demski, C., S. Capstick, N. Pidgeon, R. G. Sposato, and A. Spence, 2017: Experience of extreme weather affects climate change mitigation and adaptation responses. *Climatic Change*, **140**, 149–164, https://doi.org/10.1007/s10584-016-1837-4.

Dingle, G. W., and B. Stewart, 2018: Playing the climate game: Climate change impacts, resilience and adaptation in the climate-dependent sport sector. *Managing Sport Leisure*, **23**, 293–314, https://doi.org/10.1080/23750472.2018.1527715.

——, and C. Mallen, 2020: Community sports fields and atmospheric climate impacts: Australian and Canadian perspectives. *Managing Sport Leisure*, **26**, 301–325, https://doi.org/10.1080/23750472.2020.1766375.

Donnelly, A. A., and Coauthors, 2016: Environmental influences on elite sport athletes well being: From gold, silver, and bronze to blue green and gold. *Front. Psychol.*, **7**, 1167, https://doi.org/10.3389/fpsyg.2016.01167.

Dosio, A., L. Mentaschi, E. M. Fischer, and K. Wyser, 2018: Extreme heat waves under 1.5°C and 2°C global warming. *Environ. Res. Lett.*, **13**, 054006, https://doi.org/10.1088/1748-9326/aab827.

Flick, U., 2018: *Managing Quality in Qualitative Research*. SAGE, 168 pp., https://doi.org/10.4135/9781529716641.

González-Alonso, J., J. A. L. Calbet, and B. Nielsen, 1999: Metabolic and thermodynamic responses to dehydration-induced reductions in muscle blood flow in exercising humans. *J. Physiol.*, **520**, 577–589, https://doi.org/10.1111/j.1469-7793.1999.00577.x.

Griggs, K. E., B. T. Stephenson, M. J. Price, and V. L. Goosey-Tolfrey, 2020: Heat-related issues and practical applications for Paralympic athletes at Tokyo 2020. *Temperature*, **7**, 37–57, https://doi.org/10.1080/23328940.2019.1617030.

Guy, J. H., G. B. Deakin, A. M. Edwards, C. M. Miller, and D. B. Pyne, 2014: Adaptation to hot environmental conditions: An exploration of the performance basis, procedures and future directions to optimise opportunities for elite athletes. *Sports Med.*, **45**, 303–311, https://doi.org/10.1007/s40279-014-0277-4.

Hosokawa, Y., W. M. Adams, R. L. Stearns, and D. J. Casa, 2014: Heat stroke in physical activity and sport. *Pensar en Movimiento*, **12**, 1–21, https://doi.org/10.15517/pensarmov.v12i2.15841.

Howe, P. D., J. R. Marlon, M. Mildenberger, and B. S. Shield, 2019: How will climate change shape climate opinion? *Environ. Res. Lett.*, **14**, 113001, https://doi.org/10.1088/1748-9326/ab466a.

IPCC, 2018: Annex I: Glossary. *Global Warming of 1.5°C: IPCC Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, V. Masson-Delmotte et al., Eds., Cambridge University Press, 541–562, https://doi.org/10.1017/9781009157940.008.

——, 2021: Summary for policymakers. *Climate Change 2021: The Physical Science Basis*, V. Masson-Delmotte et al., Eds., Cambridge University Press, 3–32.

——, 2023: Summary for policymakers. *Climate Change 2023: Synthesis Report*, H. Lee and J. Romero, Eds., Cambridge University Press, https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf,%20in%20press.

Keller, C., M. Siegrist, and H. Gutscher, 2006: The role of the affect and availability heuristics in risk communication. *Risk Anal.*, **26**, 631–639, https://doi.org/10.1111/j.1539-6924.2006.00773.x.

Kellison, T. B., and S. Hong, 2015: The adoption and diffusion of pro-environmental stadium design. *Eur. Sport Manage. Quart.*, **15**, 249–269, https://doi.org/10.1080/16184742.2014.995690.

Kenefick, R. W., and M. N. Sawka, 2007: Heat exhaustion and dehydration as causes of marathon collapse. *Sports Med.*, **37**, 378–381, https://doi.org/10.2165/00007256-200737040-00027.

Lieberman, H. R., G. P. Bathalon, C. M. Falco, F. M. Kramer, C. A. Morgan III, and P. Niro, 2005: Severe decrements in cognition function and mood induced by sleep loss, heat, dehydration, and undernutrition during simulated combat. *Biol. Psychiatry*, **57**, 422–429, https://doi.org/10.1016/j.biopsych.2004.11.014.

Lorenzoni, I., and N. F. Pidgeon, 2006: Public views on climate change: European and USA perspectives. *Climatic Change*, **77**, 73–95, https://doi.org/10.1007/s10584-006-9072-z.

Maron, B. J., J. J. Doerer, T. S. Haas, D. M. Tierney, and F. O. Mueller, 2009: Sudden deaths in young competitive athletes. *Circulation*, **119**, 1085–1092, https://doi.org/10.1161/CIRCULATIONAHA.108.804617.

Marx, S. M., E. U. Weber, B. S. Orlove, A. Leiserowitz, D. H. Krantz, C. Roncoli, and J. Phillips, 2007: Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Global Environ. Change*, **17**, 47–58, https://doi.org/10.1016/j.gloenvcha.2006.10.004.

Matzarakis, A., and D. Fröhlich, 2015: Sport events and climate for visitors—The case of FIFA World Cup in Qatar 2022. *Int. J. Biometeor.*, **59**, 481–486, https://doi.org/10.1007/s00484-014-0886-5.

Maughan, R., and S. Shirreffs, 2004: Exercise in the heat: Challenges and opportunities. *J. Sports Sci.*, **22**, 917–927, https://doi.org/10.1080/02640410400005909.

McCullough, B. P., and G. B. Cunningham, 2011: Recycling intentions among youth baseball spectators. *Int. J. Sport Manage. Mark.*, **10**, 104–120, https://doi.org/10.1504/IJSMM.2011.043618.

——, M. Orr, and T. Kellison, 2020: Sport ecology: Conceptualizing an emerging subdiscipline within sport management. *J. Sport Manage.*, **34**, 509–520, https://doi.org/10.1123/jsm.2019-0294.

McDonald, R. I., H. Y. Chai, and B. R. Newell, 2015: Personal experience and the 'psychological distance' of climate change: An integrative review. *J. Environ. Psychol.*, **44**, 109–118, https://doi.org/10.1016/j.jenvp.2015.10.003.

Mihala, I., 2019: 'Hot planet, cool athletes': A case study of Protect our Winters and the role of ski activism in combating climate change. M.S. thesis, Dept. of Earth and Sciences, Institutionen för Geovetenskape, 42 pp., https://uu.diva-portal.org/smash/get/diva2:1366550/FULLTEXT01.pdf.

Miller-Rushing, A. J., R. B. Primack, N. Phillips, and R. K. Kaufmann, 2012: Effects of warming temperatures on winning times in the Boston Marathon. *PLOS ONE*, **7**, e43579, https://doi.org/10.1371/journal.pone.0043579.

Mohr, M., L. Nybo, J. Grantham, and S. Racinais, 2012: Physiological responses and physical performance during football in

the heat. *PLOS ONE*, **7**, e39202, https://doi.org/10.1371/journal.pone.0039202.

Mountjoy, M., J.-M. Alonso, M. F. Bergeron, J. Dvorak, S. Miller, S. Migliorini, and D. G. Singh, 2012: Hyperthermic-related challenges in aquatics, athletics, football, tennis and triathlon. *Br. J. Sports Med.*, **46**, 800–804, https://doi.org/10.1136/bjsports-2012-091272.

Muniz-Pardos, B., S. Sutehall, K. Angeloudis, J. Shurlock, and Y. P. Pitsiladis, 2019: The use of technology to protect the health of athletes during sporting competitions in the heat. *Front. Sports Active Living*, **1**, 38, https://doi.org/10.3389/fspor.2019.00038.

Ngo, C. C., P. M. Poortvliet, and P. H. Feindt, 2020: Drivers of flood and climate change risk perceptions and intention to adapt: An explorative survey in coastal and delta Vietnam. *J. Risk Res.*, **23**, 424–446, https://doi.org/10.1080/13669877.2019.1591484.

Nichols, A. W., 2014: Heat-related illness in sports and exercise. *Curr. Rev. Musculoskeletal Med.*, **7**, 355–365, https://doi.org/10.1007/s12178-014-9240-0.

Nybo, L., P. Rasmussen, and M. N. Sawka, 2014: Performance in the heat—Physiological factors of importance for hyperthermia-induced fatigue. *Comprehensive Physiology*, D. M. Pollock, Ed., American Physiological Society, 657–689, https://doi.org/10.1002/cphy.c130012.

Ogunbode, C. A., C. Demski, S. B. Capstick, and R. G. Sposato, 2019: Attribution matters: Revisiting the link between extreme weather experience and climate change mitigation responses. *Global Environ. Change*, **54**, 31–39, https://doi.org/10.1016/j.gloenvcha.2018.11.005.

Oikawa, Y., V. Downie, M. Tipton, D. Marlin, J. Périard, P. Castro, and J. Dyson, 2021: Rings of fire: How heat could impact the 2021 Tokyo Olympics. BASIS, 45 pp., https://basis.org.uk/wp-content/uploads/2021/09/Rings_of_Fire.pdf.

Orr, M., 2020: On the potential impacts of climate change on baseball and cross-country skiing. *Managing Sport Leisure*, **25**, 307–320, https://doi.org/10.1080/23750472.2020.1723436.

——, and Y. Inoue, 2019: Sport versus climate: Introducing the climate vulnerability of sport organizations framework. *Sports Manage. Rev.*, **22**, 452–463, https://doi.org/10.1016/j.smr.2018.09.007.

——, B. P. McCullough, and J. Pelcher, 2020: Leveraging sport as a venue and vehicle for transformative sustainability learning. *Int. J. Sustainability Higher Educ.*, **21**, 1071–1086, https://doi.org/10.1108/IJSHE-02-2020-0074.

Périard, J. D., and Coauthors, 2017: Strategies and factors associated with preparing for competing in the heat: A cohort study at the 2015 IAAF World Athletics Championships. *Br. J. Sports Med.*, **51**, 264–270, https://doi.org/10.1136/bjsports-2016-096579.

——, T. M. H. Eijsvogels, and H. A. M. Daanen, 2021: Exercise under heat stress: Thermoregulation, hydration, performance implications and mitigation strategies. *Physiol. Rev.*, **101**, 1873–1979, https://doi.org/10.1152/physrev.00038.2020.

Petro, M. T., 2011: Late-summer heat waves and their impact on hyperthermia-related deaths in football players. M.S. thesis, Geography Dept., University of Georgia, 134 pp., https://getd.libs.uga.edu/pdfs/petro_myron_t_201108_ms.pdf.

Racinais, S., M. Mohr, M. Buchheit, S. C. Voss, N. Gaoua, J. Grantham, and L. Nybo, 2012: Individual responses to short-term heat acclimatisation as predictors of football performance in a hot, dry environment. *Br. J. Sports Med.*, **46**, 810–815, https://doi.org/10.1136/bjsports-2012-091227.

——, J. D. Périard, A. Karlsen, and L. Nybo, 2015: Effect of heat and heat acclimatization on cycling time trial performance and pacing. *Med. Sci. Sports Exercise*, **47**, 601–606, https://doi.org/10.1249/MSS.0000000000000428.

——, and Coauthors, 2021: Hydration and cooling in elite athletes: Relationship with performance, body mass loss and body temperatures during the Doha 2019 IAAF World Athletics Championships. *Br. J. Sports Med.*, **55**, 1335–1341, https://doi.org/10.1136/bjsports-2020-103613.

Reser, J. P., G. L. Bradley, and M. C. Ellul, 2014: Encountering climate change: 'Seeing' is more than 'believing'. *Wiley Interdiscip. Rev.: Climate Change*, **5**, 521–537, https://doi.org/10.1002/wcc.286.

Ross, W. J., and M. Orr, 2022: Predicting climate impacts to the Olympic Games and FIFA Men's World Cups from 2022 to 2032. *Sport Soc.*, **25**, 867–888, https://doi.org/10.1080/17430437.2021.1984426.

Rutty, M., D. Scott, P. Johnson, M. Pons, R. Steiger, and M. Vilella, 2017: Using ski industry response to climatic variability to assess climate change risk: An analogue study in eastern Canada. *Tourism Manage.*, **58**, 196–204, https://doi.org/10.1016/j.tourman.2016.10.020.

Sambrook, K., E. Konstantinidis, S. Russell, and Y. Okan, 2021: The role of personal experience and prior beliefs in shaping climate change perceptions: A narrative review. *Front. Psychol.*, **12**, 669911, https://doi.org/10.3389/fpsyg.2021.669911.

Sartore-Baldwin, M. L., and B. McCullough, 2018: Equity-based sustainability and ecocentric management: Creating more ecologically just sport organization practices. *Sport Manage. Rev.*, **21**, 391–402, https://doi.org/10.1016/j.smr.2017.08.009.

Saunders, B., J. Sim, T. Kingstone, S. Baker, J. Waterfield, B. Bartlam, H. Burroughs, and C. Jinks, 2018: Saturation in qualitative research: Exploring its conceptualization and operationalization. *Qual. Quant.*, **52**, 1893–1907, https://doi.org/10.1007/s11135-017-0574-8.

Saunders, M. N. K., and K. Townsend, 2016: Reporting and justifying the number of interview participants in organization and workplace research. *Br. J. Manage.*, **27**, 836–852, https://doi.org/10.1111/1467-8551.12182.

Schneider, S., and H.-G. Mücke, 2023: Sport and climate change—How will climate change affect sport? *German J. Exercise Sport Res.*, https://doi.org/10.1007/s12662-021-00786-8, in press.

Scott, D., R. Steiger, M. Rutty, M. Pons, and P. Johnson, 2019: The differential futures of ski tourism in Ontario (Canada) under climate change: The limits of snowmaking adaptation. *Curr. Issues Tourism*, **22**, 1327–1342, https://doi.org/10.1080/13683500.2017.1401984.

——, N. L. B. Knowles, S. Ma, M. Rutty, and R. Steiger, 2022: Climate change and the future of the Olympic Winter Games: Athlete and coach perspectives. *Curr. Issues Tourism*, **26**, 480–495, https://doi.org/10.1080/13683500.2021.2023480.

Shendell, D. G., M. S. Alexander, L. Lorentzson, and F. A. McCarty, 2010: Knowledge and awareness of heat-related morbidity among adult recreational endurance athletes. *Int. J. Biometeor.*, **54**, 441–448, https://doi.org/10.1007/s00484-009-0295-3.

Smith, M. T., M. Reid, S. Kovalchik, T. O. Woods, and R. Duffield, 2018: Heat stress incident prevalence and tennis matchplay performance at the Australian Open. *J. Sci. Med. Sport*, **21**, 467–472, https://doi.org/10.1016/j.jsams.2017.08.019.

Smith, N., and H. Joffe, 2013: How the public engages with global warming: A social representations approach. *Public*

Understanding Sci., **22**, 16–32, https://doi.org/10.1177/0963662512440913.

Soligard, T., and Coauthors, 2023: New sports, COVID-19 and the heat: Sports injuries and illnesses in the Tokyo 2020 Summer Olympics. *Br. J. Sports Med.*, **57**, 46–54, https://doi.org/10.1136/bjsports-2022-106155.

Spence, A., W. Poortinga, C. Butler, and N. F. Pidgeon, 2011: Perceptions of climate change and willingness to save energy related to flood experience. *Nat. Climate Change*, **1**, 46–49, https://doi.org/10.1038/nclimate1059.

Swann, C., A. Moran, and D. Piggott, 2015: Defining elite athletes: Issues in the study of expert performance in sport psychology. *Psychol. Sport Exercise*, **16**, 3–14, https://doi.org/10.1016/j.psychsport.2014.07.004.

Swanson, R. A., and E. F. Holton, 2005: *Research in Organizations: Foundations and Methods of Inquiry*. Berrett-Koehler Publishers, 481 pp.

Taylor, N. A. S., 2000: Principles and practices of heat adaptation. *J. Hum. Environ. Syst.*, **4**, 11–22, https://doi.org/10.1618/jhes.4.11.

Vaismoradi, M., H. Turunen, and T. Bondas, 2013: Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nurs. Health Sci.*, **15**, 398–405, https://doi.org/10.1111/nhs.12048.

van der Linden, S., 2015: The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. *J. Environ. Psychol.*, **41**, 112–124, https://doi.org/10.1016/j.jenvp.2014.11.012.

Wang, S., Z. Leviston, M. Hurlstone, C. Lawrence, and I. Walker, 2018: Emotions predict policy support: Why it matters how people feel about climate change. *Global Environ. Change*, **50**, 25–40, https://doi.org/10.1016/j.gloenvcha.2018.03.002.

Waters, J., 2015: Snowball sampling: A cautionary tale involving a study of older drug users. *Int. J. Soc. Res. Methodol.*, **18**, 367–380, https://doi.org/10.1080/13645579.2014.953316.

Weber, E. U., 2006: Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change*, **77**, 103–120, https://doi.org/10.1007/s10584-006-9060-3.

——, 2010: What shapes perceptions of climate change? *Wiley Interdiscip. Rev.: Climate Change*, **1**, 332–342, https://doi.org/10.1002/wcc.41.

Whitmarsh, L., 2008: Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. *J. Risk Res.*, **11**, 351–374, https://doi.org/10.1080/13669870701552235.

Wicker, P., 2018: The carbon footprint of active sport tourists: An empirical analysis of skiers and boarders. *J. Sport Tourism*, **22**, 151–171, https://doi.org/10.1080/14775085.2017.1313706.

Yankelson, L., and Coauthors, 2014: Life-threatening events during endurance sports: Is heat stroke more prevalent than arrhythmic death? *J. Amer. Coll. Cardiol.*, **64**, 463–469, https://doi.org/10.1016/j.jacc.2014.05.025.

Zaval, L., E. A. Keenan, E. J. Johnson, and E. U. Weber, 2014: How warm days increase belief in global warming. *Nat. Climate Change*, **4**, 143–147, https://doi.org/10.1038/nclimate2093.