

SWELTERING HEAT AT THE 2020 OLYMPICS IN TOKYO

SPORTIFY CITIES Report

By Chris Szubski



KEY POINTS OF THIS REPORT:

- Temperatures and humidity levels at the 2020 Summer Olympics in Tokyo could greatly weaken an athlete's performance and increase the risk of heat stroke.
- Assessment of the severity and probability levels of sweltering temperatures at the upcoming 2020 Olympics.
- During Tokyo's summer period 'feels like' temperatures regularly exceed 45°C.
- The comparative analysis across Olympic Cities indicates that athletes competing in Tokyo could potentially be exposed to the most challenging meteorological conditions ever observed in the modern history of the Olympic Games.
- Proposals for the incorporation of suitable heat acclimatisation strategies into pre-Olympics training and performance diagnostics cycles.
- Recommendations for suitable locations for heat acclimatisation purposes.
- The heat factor is expected to become one of the key defining planning features of a pre-Olympics training preparation cycle for many athletes aspiring to compete at the 2020 Summer Olympic and Paralympic Games.

THE HEAT FACTOR AT THE 2020 OLYMPICS

The 2020 Olympic Games in Tokyo will be held during the city's summer period, which is the hottest and most humid time of the year. Tokyo's climate is classified as 'humid subtropical' — based on the regularly used *Köppen climate classification* system. This is not necessarily a suitable climate zone for holding outdoor sporting events. After all, it has been proven that non-acclimatised athletes tend to under-perform when exposed to extremely high temperatures and high humidity levels. They typically experience a decline in sporting performance due to hyperthermia (the risk of medical emergencies is increased, too). That is, failed thermoregulation leads to elevated core body temperature, which typically results in impaired cognitive functioning, reduced complex task levels and/or diminished response of the cardio-respiratory system.

Given that a large proportion of potential Olympians are not accustomed to subtropical or tropical climate conditions (that is, they mostly reside and train in other climate zones), this report hopes to provide prospective 2020 Olympic athletes with practical knowledge of typical temperature and humidity levels during the summer period in Tokyo.

HIGH TEMPERATURES AND HUMIDITY IN TOKYO

Standard climate diagrams of Tokyo imply that this city located in East Asia offers fairly acceptable ambient conditions for sporting performance, with mean high air temperatures of approximately 30°C being monitored during the peak summer period. By design, however, such climate diagrams only indicate the average values observed over long periods of time (usually over several decades), concealing the wide range in daily temperatures, humidity levels or rainfall. Standard diagrams therefore fail to provide athletes and coaches with meaningful information about the potential meteorological circumstances at the 2020 Olympics.

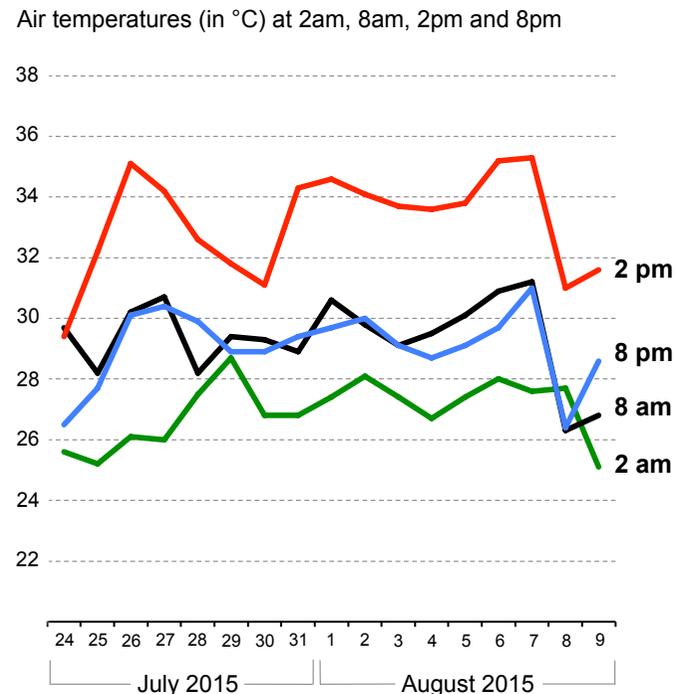
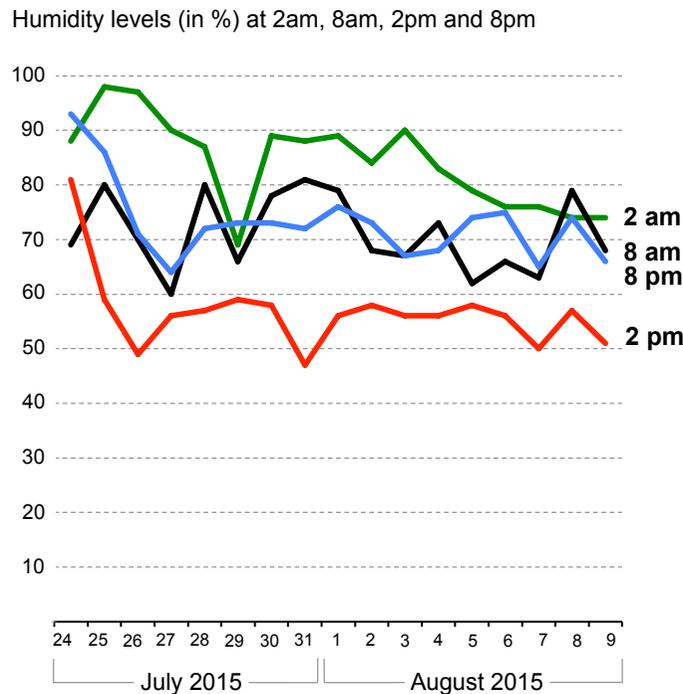
To begin with, athletes who intend to participate at the upcoming Tokyo Olympics are advised to examine the day-by-day and hour-by-hour variation of meteorological raw data during exemplary peak summer periods in Tokyo; that is, the months of July and August are of particular importance to all athletes and coaches.

Graph 1, for instance, illustrates the air temperatures and humidity levels monitored at four different times of a day, starting on 24 July and ending on 9 August 2015 – the same calendar days during which the 2020 Olympics will take place. As Tokyo is under a strong and

stable influence of subtropical winds originating from the Pacific Ocean during its peak summer season, this graph reflects a plausible trend of air temperatures and humidity levels that could be expected during the 2020 Olympic Games period. The 8am and 8pm values, for instance, are crucial to athletes, as many qualification and elimination contests will be scheduled during morning hours, whereas the main competitions will, by and large, be carried out in the early and late evening hours. As for the hundreds of thousands of event visitors who will spend much of their daytime outdoors, the awareness of the temperature levels at 2pm is certainly critical.

Graph 1. Plausible humidity levels and air temperatures over the course of the 2020 Olympics (based on data recorded in 2015)

Exemplary humidity and temperature patterns during the scheduled 2020 Olympic Games period



Source: Japan Meteorological Agency

As demonstrated in **Graph 1**, Tokyo's morning air temperatures typically reach 30°C, while the relative humidity levels are still high, mostly fluctuating between 60 and 80% (if no rain is reported). In the afternoon the maximum air temperatures — measured in the shade — exceed 35°C on regular basis. And on a sunny day in July and August the relative humidity levels in Tokyo remain fairly high, barely dropping below the 50% levels.

In the early evenings, the air temperatures typically drop below 30°C, while the humidity levels start rising rapidly again, reaching values of slightly above 70% during evenings with no reported rainfall. Athletes who will have to get up later at night in order to get ready for their events scheduled in the very early morning hours need to be aware of the fact that the night air temperatures barely drop below 27°C and that the humidity levels regularly remain above 80%.

These observational data clearly demonstrate that many athletes and event visitors are likely to be exposed to challenging temperatures and humidity levels throughout the scheduled competition period. This includes athletes competing during the supposedly comfortable morning hours, given that air temperatures usually rise fairly quickly, reaching almost intolerable levels by 11am. On top of this, the intense solar ultraviolet radiation prevailing during Tokyo's summer rapidly inflates the heat factor throughout the morning (this performance-affecting aspect of sun exposure is not reflected in the standard air temperature – which is measured by a thermometer located in the shade). The only time of relief appears to be in the early and late evenings; however, after sunset the rising humidity levels usually offset the slightly lower and more comfortable air temperatures.

Tokyo's high air temperatures during its summer period will almost certainly have a significant impact on athletes' individual performances at the 2020 Olympics. Air temperature in itself, however, will not be the key challenge. It is Tokyo's combination of higher air temperatures and high humidity levels, which could potentially result in the most challenging conditions ever observed in the modern history of the Olympic Games.

FEELS LIKE TEMPERATURES

To get better insights into the actual body's perception of the heat factor during the upcoming 2020 Olympics in Tokyo, humidity would need to be factored into the standard air temperatures. For instance, the assessment of the 'feels like' or 'perceived' temperature (or 'heat index') would be more telling, as this calculated value takes into account the air temperature and humidity level.

Due to the weighty influence of humidity on tangible temperature levels, a recorded air temperature of 30°C, for example, can be perceived as 30°C in one part of the world, whereas elsewhere it feels more like 40°C. In other words, identical air temperatures recorded at various locations around the globe get perceived differently.

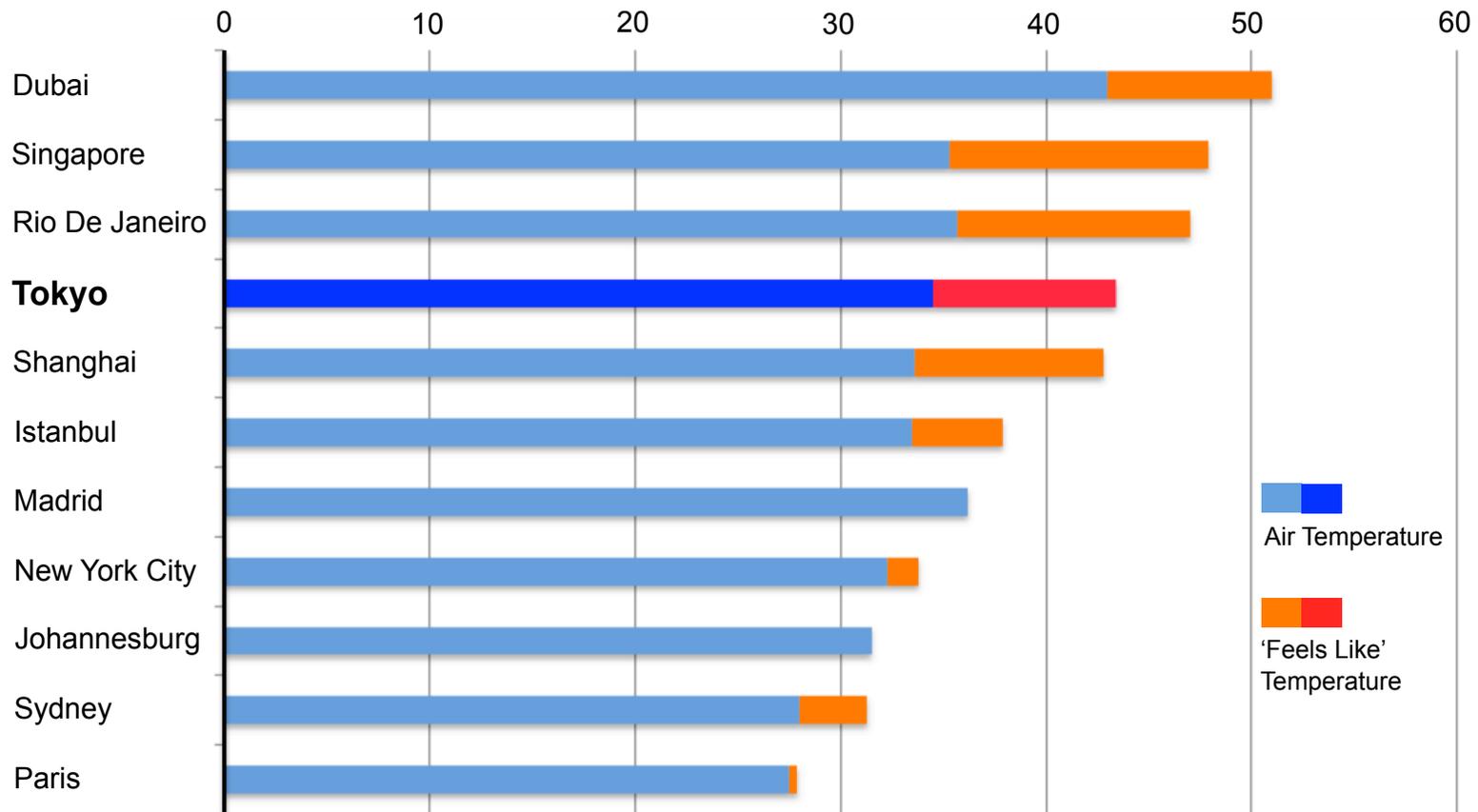
During Tokyo's summer the 'feels like' or 'perceived' daytime temperatures regularly exceed the 45°C mark — occasionally, the extraordinary levels of 50°C are reached. And the high 'feels like' morning temperatures of above 40°C indicate that even athletes participating in qualification and elimination contests (which are typically scheduled during morning hours) will also have to endure harsh meteorological conditions. Based on these measurable observations, many 2020 Olympians competing in the daytime will be exposed to extreme ambient environments.

To help athletes gain better understanding of the dimension of the heat factor facing them during the 2020 Olympics, it is worth matching Tokyo's 'feels like' temperatures with the observed levels in other cities around the world — as illustrated in **Graph 2**. As most people understandably struggle to make sense of abstract meteorological numbers, such comparative figures could provide them with real-life reference points. It is, after all, reasonable to assume that peoples' subjective perception of temperatures experienced in any of the selected cities could possibly enable them to better relate to these rather abstract values.

Graph 2. Average maximum 'feels like' temperatures in selected cities observed during the cities' seasonal summer period.

Mean maximum temperatures during the meteorological summer period of 2015

Maximum air temperature* and maximum 'Feels Like' temperature* in selected cities, in °C



* Average values during the hottest 1-month-period

Source: World Weather Online, Dataset

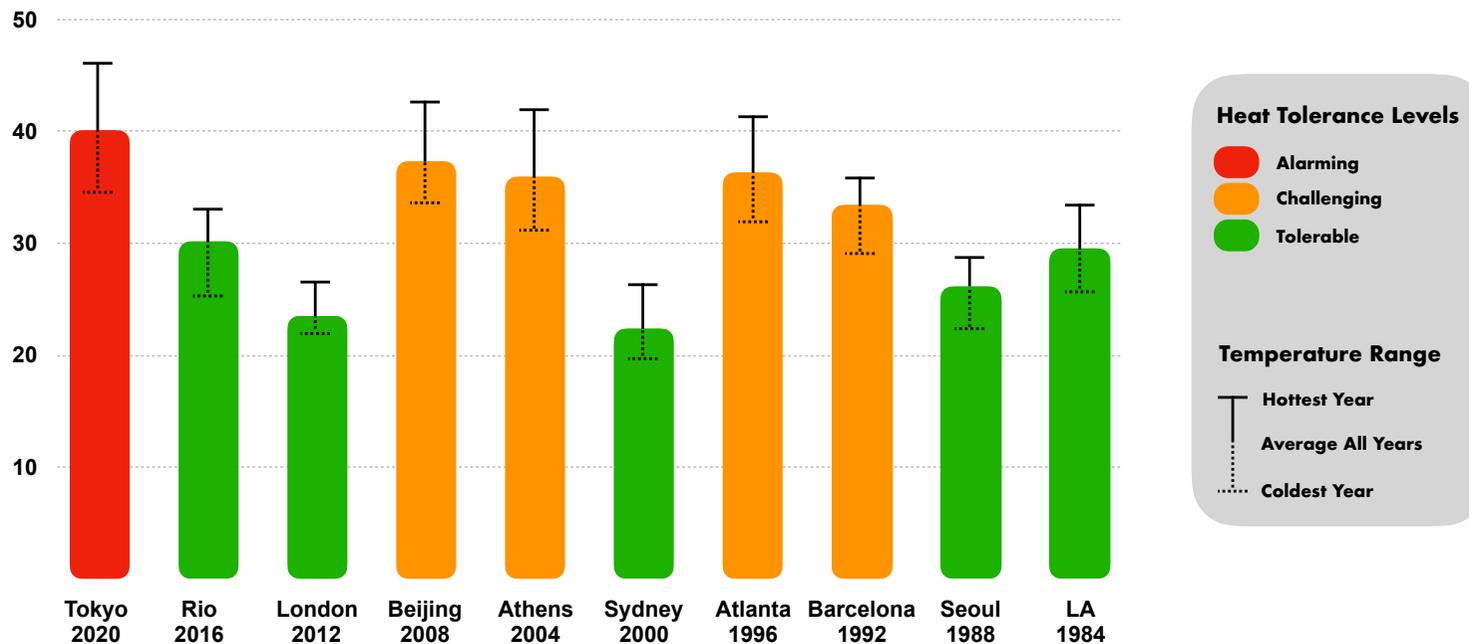
Graph 3 displays an exemplary range of maximum ‘feels like’ temperatures of Summer Olympic Cities of the past four decades. For this comparison, meteorological data of all cities were compiled for any given period during which the specific Olympic Summer Games took place. By nature, temperatures and humidity levels — among other meteorological variables — fluctuate on year-to-year basis, with some geographic locations demonstrating larger variations than others. To minimise the risk of an outlier effect, ‘feels like’

temperatures for nine consecutive years, from 2008 to 2016, were collected and averaged for this comparison. The graph indicates that although the Games in Atlanta (1996), Athens (2004) and Beijing (2008) were, too, scheduled during the cities’ hot summer periods, their ‘feels like’ temperatures are no match to the potentially extreme levels during the upcoming 2020 Olympics in Tokyo. In fact, no other host city of the Modern Olympic Games, dating back to 1896, demonstrates such challenging heat levels.

Graph 3. Comparative ‘feels like’ temperatures in various Olympic Cities.

OLYMPIC CITIES AND THE HEAT FACTOR

Mean maximum ‘Feels Like’ temperatures between 2008 and 2016 during a given Summer Olympic Games period (in °C)



Source: World Weather Online, Dataset

The weather conditions in Tokyo were particularly harsh during the summer periods of 2014, 2015 and 2016, with average 'feels like' temperatures ranging from 41 to 45°C in three consecutive years. It is entirely possible, however, that the heat levels will be less severe during the 2020 Summer Olympics. If the coastal regions of East Asia are under a strong influence of wet weather systems originating from the Pacific Ocean during the summer period in 2020, the 'feels like' temperatures could possibly drop to as low as 35°C during the 2020 Olympic Games. Yet although this is the best-case scenario for Olympians, the occurrence of such subtropical wet weather systems, on the other hand, would certainly lead to even higher humidity levels.

The upcoming 2020 Paralympic Games in Tokyo will also be held during the summer period, starting on 25 August and finishing on 6 September. Yet thanks to the increasing number of wet and slightly cooling low-pressure systems frequently passing through the region in August and September, local temperatures during the 2020 Paralympics are expected to be slightly lower compared to the 2020 Olympic Games levels. As illustrated in **Graph 4**, the maximum *feels like* temperatures in Tokyo typically range between 30°C and 43.5°C during late August and early September. It is therefore reasonable to assume that the 2020 Paralympics in Tokyo could become the hottest event in the history of the Paralympic Games. To complicate things further at the 2020 Paralympics, the greater likelihood of typhoon events during the late summer season could result in high volumes of rainfall and major interruptions to the schedule.

Taken together, athletes planning to compete at the 2020 Olympics or Paralympics can not count on pure luck. Although this report does not claim to be able to predict the meteorological conditions during the 2020 Olympics, it highlights the potential risk of heat exposure for

prospective athletes and visitors alike and the importance of undertaking the necessary climate acclimatisation measures.

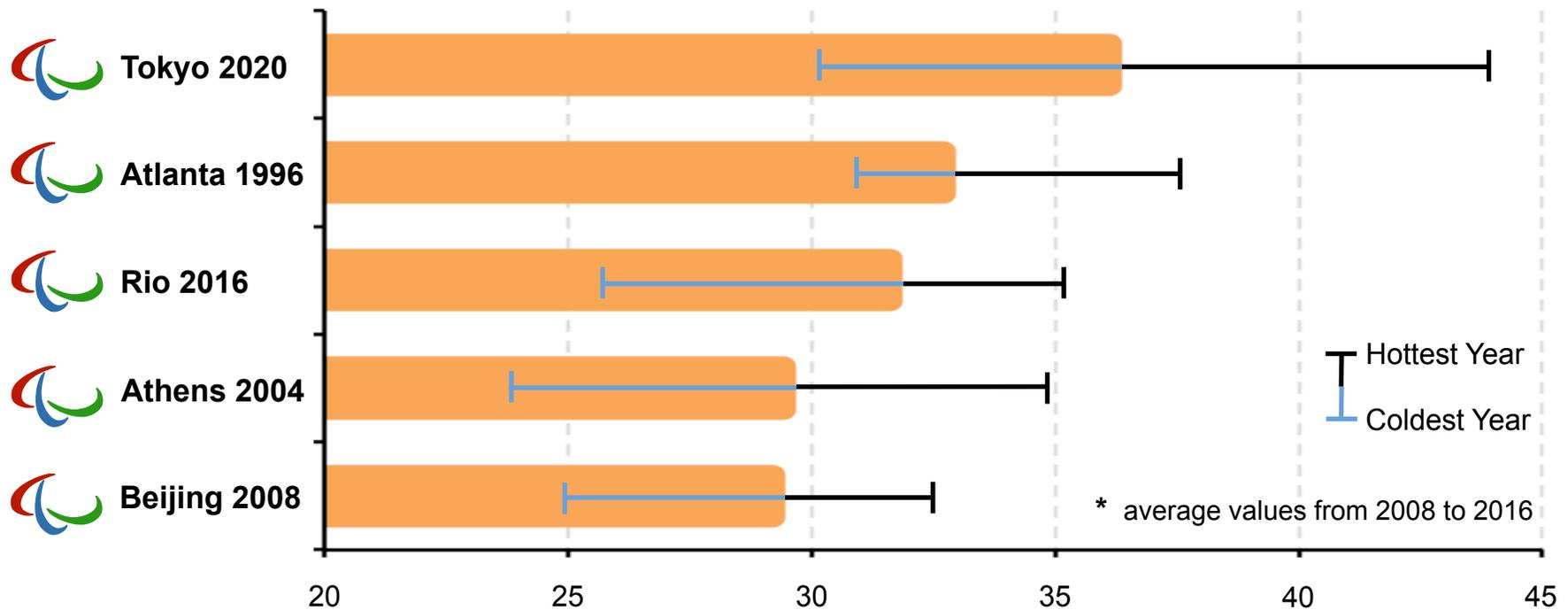
To underline the importance of adequate training preparation and heat acclimatisation procedures for the Olympic Games in Tokyo, one should recall the 8th of August 2008; on this particular day the maximum 'feels like' temperature observed in Tokyo reached staggering 55°C. Besides, all prospective Olympic athletes should bear in mind that the effects of solar radiation are yet to be factored in. In the European Journal of Applied Physiology, an academic journal, *Otani* and his colleagues have recently demonstrated that, for instance, endurance exercise performance in hot environments weakens progressively as solar radiation increases. According to the Australian Bureau of Meteorology, direct sun exposure in the middle of the day could add as much as 8°C to the 'feels like' temperatures – that is, perceived heat levels on a sunny day with high air temperatures and humidity levels could potentially reach almost 60°C (!) in Tokyo.

Given such extreme heat conditions and periods of consecutive sunny days during Tokyo's peak summer period, this information on solar radiation would also need to be taken into consideration before planning and constructing the key 2020 Olympic facilities. In particular, the artificial islands located in the Tokyo bay zone – many Olympic sporting venues and the Olympic village will be built around this key waterfront area – should be designed with vast parkland space consisting of large numbers of subtropical trees so as to provide the largely non-acclimatised event visitors with the much-needed shade and to reduce the extremely high heat levels around the large-scale sporting facilities (particularly, visitors with pre-existing heart conditions are at high risk).

Graph 4. The five warmest host cities of the Summer Paralympic Games (based on observations during a given Paralympics period).

Paralympic Host Cities and the HEAT factor

Mean maximum 'Feels Like' temperatures during a given Paralympic Games period*, in °C



Source: World Weather Online, Dataset

ACCLIMATISATION MEASURES FOR OLYMPIC ATHLETES

To be able to perform at the highest possible levels at the 2020 Olympic Games in Tokyo, potential athletes will have to incorporate the heat factor into their pre-Olympics training cycles — that is, the systematic scheduling of hot and humid environments into their training cycles. Furthermore, personalised, time-dependent acclimatisation progression will need to be assessed at least one year prior to the Olympics, while taking into account the differing physical requirements of the sports.

Surprisingly, however, among top athletes the implementation of heat acclimatisation protocols is not as common as one would expect. According to a survey by *Périard* and his colleagues only 15% of professional track and field athletes participating at the 2015 World Athletics Championships in Beijing appeared to have incorporated heat-acclimatisation training regimes into their preparation cycles in the lead to the championship (the temperatures and humidity levels at the upcoming 2020 Tokyo Olympics are expected to be substantially higher than in Beijing). Given that the large majority of all competing professional athletes at the World Athletics Championships in Beijing represented countries that are not located in subtropical/tropical climate zones, this high proportion of non-heat-acclimatised competitors (85% of all surveyed athletes) indicates that potential Olympians would have to take the heat preparation more seriously.

Again, adequate heat acclimatisation procedures are crucial to maintaining the neuromuscular and metabolic functioning when performing under hot and humid conditions. In this way, the individual heat tolerance levels can be increased and the risk of sporting under-performance can be minimised through higher efficiency of heat-regulating mechanisms of the body. Regarding the suitability of heat acclimatisation procedures, the use of generic acclimatisation chambers is an acceptable option for athletes competing in individual endurance sports and wanting to get accustomed to heat and humidity conditions; yet their limited space makes them a highly inefficient and restrictive choice for larger national teams, game sports and sports-

specific, multi-functional tasks. As a result, their role is largely limited to standardised training assessments on cycle-ergometers, treadmills or rowing machines.

Spending longer periods of time in a naturally hot and humid ambient environment that is identical to the likely meteorological conditions during the 2020 Olympics will therefore be the more effective heat acclimatisation procedure in a pre-Olympics training cycle. In this way, individual athletes as well as large teams will get accustomed to the challenging circumstances — i.e., the naturally hot and humid environment — and, at the same time, execute sports-specific tasks for longer periods of time. During such acclimatisation training camps of two to three weeks (this duration has been considered to be sufficient, according to a recent consensus article published in the academic *British Journal of Sports Medicine*) personalised information on the acclimatisation process of physiological, neuromuscular and cognitive parameters would frequently need to be gathered in high-performance laboratories, guiding coaches in the development of the most suitable acclimatisation patterns for their athletes. In order to boost overall performance levels during such brief heat acclimatisation training cycles, however, high-intensity and high-volume sports-specific training sessions should regularly be carried out in a more pleasant environment — that is, in air-conditioned gyms and sport halls.

One of the key challenges for national performance diagnostics analysts and coaches will be to correctly interpret the latest basic and applied research findings published in academic journals and to implement personalised acclimatisation testing outcomes into their athletes' real-life training and performance cycles. On the other hand, thanks to the evolution of wearable technology in the sporting industry, the application of novel, wearable devices measuring relevant thermal variables as well as physiological parameters will most likely become the tools of choice, enabling national teams and their performance diagnostics professionals to gather more personalised information in hot and humid natural environment. In this regard, however, it needs to be underlined that the performance of an athlete must not be

confined solely to physiological parameters. To date, exercise physiologists have been dominating the research work on heat acclimatisation and performance, largely focussing on assessing physiological parameters and applying aerobic, endurance testing protocols. Hence, very little is known about the impact of high temperatures and humidity levels on non-endurance sporting tasks and other key components of an athlete's overall performance, including mood, irritability, intrinsic motivation, sleep quality, neuromuscular coordination, concentration capability or cognitive capacity — to name a few. And investigations on the adaptation patterns of these crucial factors during longer heat-acclimatisation periods are also absent. Given that research studies have yet to provide clear insights into the relationship between heat exposure and the above-mentioned fundamental elements of sporting performance, it should not be prematurely argued that the performance in brief, anaerobic and high-skill sporting tasks remains stable and unaffected among non-acclimatised athletes who are exposed to high temperatures and humidity levels during sporting events. To be clear, non-endurance athletes should also implement heat-acclimatisation protocols into their pre-Olympics training cycles.

As for the prospective 2020 Olympians who live and train in locations within tropical climate zones, i.e., the so-called tropical natives, heat acclimatisation-related trips to other countries can be largely avoided. After all, the all-year-round temperature and humidity levels in most parts of the world's tropical regions typically reach identical or even higher levels that are likely to be experienced during the Tokyo 2020 Olympics period. It has been speculated, however, that additional artificial heat exposure could perhaps result in enhanced tolerance to hot and humid conditions among athletes who are already naturally accustomed to hot and humid conditions. In this regard, it will be interesting to observe whether the exercise physiology & performance research community can establish such novel acclimatisation protocols prior to the 2020 Olympics, potentially giving trained tropical natives substantial performance advantage over heat-acclimatised tropical non-natives. According to *Jason KW Lee*, an expert on this topic and an Associate Professor at the National University of

Singapore, there is scope for acclimatisation programs of greater exercise intensity or higher heat-humidity in trained tropical natives.

Regular acclimatisation testing procedures should also include the personalised assessment of the most relevant sports-specific physical conditions, food and fluid intake requirements as well as the most suitable cooling options. Although this report does not discuss the effectiveness of conventional on-site strategies for reducing athletes' core temperatures under hot and humid conditions, such as cooling, fluid intake or clothing, it needs to be pointed out that all prospective Olympians can, of course, adopt a series of measures to reduce the heat-related risk of performance decline during the 2020 sporting event. Devoted national coaches who feel comfortable applying scientific knowledge into practice should therefore be referred to some excellent scholarly work on this topic that has over the years been conducted by *Samuel N Cheuvront* (Natick, Massachusetts, USA), *Jason KW Lee* (Singapore) and *Rob Duffield* (Sydney, Australia).

ACCLIMATISATION SUITABILITY OF SELECTED REGIONS

For many top-sporting nations, capital-intensive sports teams and national sports federations with limited budgets, however, the provision of the most efficient acclimatisation options for their Olympic athletes will eventually become a logistic and financial issue. For one thing, subtropical climate conditions are absent in numerous countries with long sporting tradition. For another, if national sports organisations choose to invest into overseas trips for heat acclimatisation and training purposes, adequate access to high-quality sporting infrastructure and provision of in-built high-performance diagnostics facilities will need to be guaranteed.

Top sporting nations with suitable climate conditions:

- **Japan**, as the host nation of the 2020 Olympics, will surely be in an advantageous position regarding the provision of a wide range of heat acclimatisation localities for their top athletes. Its subtropical climate will enable the country's athletes to carry out some

segments of their pre-Olympics training preparation under inhospitable ambient conditions — that is, hot and humid weather. After all, during the fairly long and stable summer period of two months much of the country's southern and middle region is perfectly suited for training camps and large-scale acclimatisation assessments.

- The top-tier sporting nation of **China** is also in a formidable position. Many urban locations in the country's south-eastern region — for instance, in the *Guangdong* province — present very high *feels like* temperatures for as long as 3 to 4 months, providing its national Olympic teams with extensive training and high-performance diagnostics options.
- In **South Korea** suitable temperatures and humidity levels typically prevail for several weeks during the country's summer season. That said, Tokyo's levels of extremely high *feels like* temperatures can not be reached.
- The **USA** Olympic team, too, is in an enviable position; the areas around the cities of Houston and New Orleans demonstrate suitable *feels like* temperatures during the months of July and August. The provision of high class-sporting facilities in these regions is a further boon for its national teams.
- **Australia**, another top-tier sporting nation, is also lucky to have suitable acclimatisation options in the northern region of *Northern Territory* and the north-eastern parts of *Western Australia*. Darwin, for instance, could serve as a training base during the 6 months long rain season, during which the *feels like* temperatures typically range between 40 and 55°C. However, it is not an ideal location choice for the pre- Olympics heat acclimatisation period, as the highest temperatures and humidity levels prevail solely between November and April (whilst the Tokyo 2020 Olympic Games will begin in mid-July).
- **Brazil**, the host country of the 2016 Olympics, is largely located in tropical and subtropical climate zones. It has countless training and high-performance diagnostics sites to choose from.

By contrast, all European countries (including Russia) lack suitable climate zones altogether. Although the southern regions of the continent show fairly high air temperatures during the European summer, they are, by and large, associated with low levels of humidity. And although the western and central parts of Europe usually experience a number of hot and humid summer days, these heat wave periods are far too short and too irregular to be incorporated into Olympic preparation cycles in any meaningful way. In Russia, only the city of Sochi, located at the Black Sea, reaches *feels like* temperatures of above 40°C. Yet its limited number of high temperature days between the end of July and mid August makes Sochi a rather unsuitable heat acclimatisation location during the pre-Olympics period.

In all, it becomes evident that at the Tokyo 2020 Olympics the sporting nations located in non-sub-tropical climate zones as well as national teams with limited financial resources — and especially the Paralympic national teams — could end up being in a disadvantageous position compared to the countries mentioned above. For the affected sporting teams it is therefore highly recommended to arrive two to three weeks ahead of the Games so as to at least enable their athletes to acclimatise to the local subtropical climate in a timely manner. National Olympic Committees, coaches, high-performance diagnostics experts and Olympic athletes representing the better-off countries, that is, countries with accessibility to subtropical climate zones, will, on the other hand, need to strike a balance between regular performance development of their athletes and efficient acclimatisation measures. Much of the pre-Olympics training preparation cycle will surely be carried out in more pleasant temperatures and humidity levels, ensuring the optimisation of athletic performance. Yet simultaneously, personalised heat and humidity acclimatisation periods consisting of various optimal durations will have to be implemented into the training cycle without jeopardising the overall performance evolution of athletes.

HEAT - THE KEY PERFORMANCE FACTOR

Preparations for the 2020 Olympics will undoubtedly pose challenges to all involved sporting team members, not least because heat-acclimatisation procedures will need to be tailored specifically to the physical requirements of each sports. Yet if managed successfully, it could prove to be one of the defining features of individual performance during the potentially most sweltering Olympic Games in modern history.

This report aims to outline, illustrate and discuss the probable heat conditions during the Tokyo 2020 Olympics for mainly two reasons. For one thing, athletes should be provided with this crucial information a couple of years prior to the Games so that this knowledge and personalised acclimatisation datasets can be effectively incorporated into pre-Olympics training preparation cycles. For another, the event organisers will have to establish a well-thought-out competition scheduling so as to reduce the levels of discomfort for both athletes and spectators. Likewise, the provision of large numbers of resting zones containing air-conditioning areas and sun protective features will most certainly have to become an essential element of the newly built sporting infrastructure.

To be clear, this report does not intend to paint a bleak picture of the meteorological situation during the upcoming 2020 Olympics in Tokyo. Rather, it is an informative overview of the probable temperatures and humidity levels, which should be circulated among professional athletes, coaches, National Olympic Committees and event organisers. And yet it may just be a matter of time before national sports organisations and the international media start addressing this subject of heat exposure, which could potentially become one of the most-discussed topics ahead of the 2020 Summer Olympic Games.

The original report published in July 2016 has been updated with additional information.

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