

# The relevance of a shading/ roofing on elite 3x3 players: exertional heat stress, performance & injury prevention

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## 1. Background

3x3 basketball is a discipline of basketball, governed by the International Basketball Federation (FIBA) and has become an Olympic discipline with its inclusion to the Tokyo 2020 Olympic Games.

Some relevant physical and physiological characteristics of 3x3, underlying the present white paper, include:

- 1) The relative intensity of competition is twice that of traditional basketball.
- 2) Although 3x3 players cover far less distance during a game compared to traditional basketball, the heart rate response as a percentage of maximal is high, and similar to that of traditional basketball. This is also true of lactate, indicating that although players must compete in a confined space, the higher relative intensity of these movement demands contribute to relatively high lactate responses.

More information in this regard can be found [here](#).

The 3x3 game is often described as a game-long-sprint as there is little to no rest during the 10-minute net playing time. Put differently, players must maintain their highest physical performance during the 20 minutes overall game duration. The reason for the restless high intensity lays in the following: Dead-ball situations are significantly fewer and shorter compared to basketball (5v5) and other comparable outdoor team sports. Time-outs are rare and short, dead ball situations are kept short and if no call by a referee, the game continues permanently with no time to take a breather. For example, following a basket there is no dead-ball situation, the opposite team immediately continues the play. Teams often play 2 or more games in a competition day.

3x3 basketball is played on an outdoor, half-court, with only one basket. Event venues are typically temporary venues, installed in busy urban areas.

FIBA coordinates the 3x3 competition schedule, which is composed of national team competitions and the 3x3 World Tour (for men) and the 3x3 Women's series. World Tour Masters are typically played by hosting group stages, followed by knock-out stages, with participating teams having a chance to qualify for the World Tour Final. The vast majority of 3x3 events take place in summer and/ or in warmer regions to accommodate the outdoor sport format.

Taking the above into consideration, the present white paper has been produced to evaluate the possible needs and benefits of providing shading/ roofing for 3x3 basketball venues when it comes to: exertional heat stress, player performance and injury prevention.

To do so, the authors of this white paper have assessed several crucial factors against the following hypothesis:

*"A canopy is a necessity in elite 3x3 to protect athletes from extreme environmental conditions (heat, sun, rain). 3x3 is a high intensity physical exercise and no shading may lead to:*

- *higher level of physical stress;*
- *Risk of heat stress (heat stroke, heat exhaustion, etc.);*
- *Lower performance; and*
- *Higher risk of injury."*

Methodological note: this paper is based on a profound literature review and conclusions have been drawn in line with the subject matter expertise of the authors (who are independent researchers and medical doctors, not affiliated to any FIBA commission).

## **2. Factors to take into account when assessing heat impact on elite 3x3 players**

When assessing the potential benefits of shading/ roofing of 3x3 outdoor venues by installing a canopy, there are several factors to take into consideration. The below-listed factors will be assessed throughout the present white paper. Consequently, this section aims to provide a summary of relevant factors and briefly describes and defines each of these factors.

### **Environmental Factors**

- **Heat and Humidity**

Heat and humidity have significant physiological impacts on athletes. High environmental temperatures lead to increased body temperatures and heart rates, potentially leading to heat exhaustion or heatstroke. Humidity exacerbates the situation by impairing sweat evaporation, the body's primary cooling mechanism, leading to an increased risk of hyperthermia.

- **Solar Radiation**

Sun radiation not only contributes to heat stress but can also cause sunburn and potentially heat-related illnesses. Ultraviolet (UV) radiation from the sun can cause skin damage and eye injuries.

### **Individual Factors**

- **Physiological Characteristics of 3x3 Players and the Game**

3x3 basketball players are typically exposed to high-intensity bouts of physical activity with minimal recovery times, contributing to increased internal body temperature. Individual differences such as level of acclimatization, fitness, hydration status, and body composition can influence the risk of exertional heat stress.

## Other Specific Factors

- **Mentality in Professional Sport**

Professional athletes often push their physical limits to achieve competitive advantages, potentially leading to disregard for the signs of exertional heat stress. This mindset could contribute to a higher risk of heat-related illnesses.

- **Travel and Lack of Acclimatization**

Travelling across time zones and climates without adequate time to acclimate can affect the body's ability to manage heat stress effectively. This is especially relevant for elite athletes, in 3x3 as events typically last only two days and the overall stay in a hosting city is commonly no longer than four or maximum five days.

## **3. Exertional heat stress**

The combination of heat and physical work is one of the greatest stresses on the human organism. Within a short time, it can lead to drastic performance losses and sudden life-threatening crises. The risk of a heat incident increases enormously when athletes exert themselves to the maximum and this takes place in high air temperatures, high humidity and under strong sunlight. Due to the low temperature tolerance (increase to approx. 40°C body core temperature), actually uncritical, moderate exercise intensities can under heat conditions suddenly trigger a life-threatening heat stroke.

In the following, important basic information is provided on (1) heat dissipation in the human organism (2) on factors influencing heat tolerance (3) on recognising and reacting correctly in heat emergencies. Finally, it deals with (4) effective prevention and emergency measures and the question of whether a canopy is necessary for high intensity 3x3 basketball.

### **a) Heat emission in the human body**

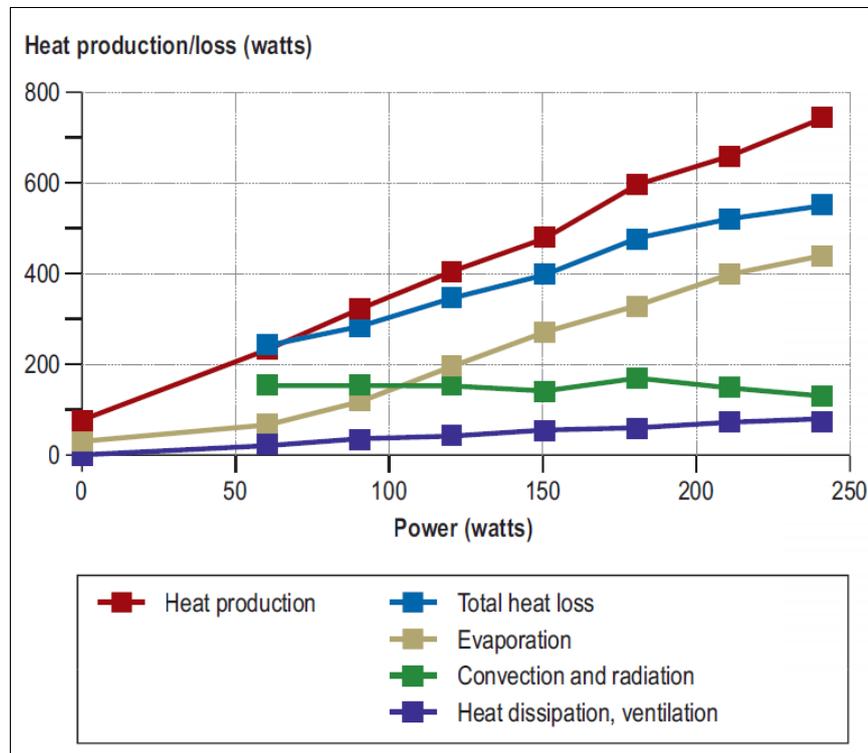
Even at physical rest, high ambient temperatures, high humidity and no wind can cause considerable heat stress in the organism. The health hazards are usually underestimated, even though there are said to be more than 25,000 heat-related deaths in Europe every year.

The average core body temperature of humans is around 37° C. It is precisely regulated and the physiological range of fluctuation is only about 2° Celsius. Even with fever, body temperatures rarely rise above 40° Celsius.

Under resting conditions, the organism produces about 5-6 KJ of heat per minute. Without heat release, the body would thus heat up by an amount of around 300-360 kJ per hour. During physical exertion in work, leisure and sport, heat production can exceed 3,500 KJ/hour. This is due to the strong and rapid heat production in the working muscles. Only under optimal conditions (e.g. cycling) can 20-25% of the energy be used mechanically; the majority is released in the form of heat. This explains why core body temperatures of 39-40°C can be reached within 10-20 minutes at high exercise intensities. In occupational medicine, there is a recommendation to end heat stress when a core body temperature of 38.5°C is reached.

It is obvious that the organism must have efficient mechanisms to prevent dangerous increases in body temperature. At physical rest, heat is released via thermal radiation (approx. 60%), conduction and convection (approx. 15%), evaporation (approx. 25%).

During physical work or at high ambient temperatures, large amounts of heat are released primarily through sweat evaporation. Sweating is the most important physiological heat dissipation mechanism in humans, accounting for approx. 70-80%. Figure 1 shows that the increase in heat work is primarily due to increased sweat evaporation. Above 35° C ambient temperature, heat can practically only be dissipated through sweating. At high humidity, however, heat dissipation through sweat evaporation is massively restricted, which leads to enormous performance losses and great health hazards.



**Fig. 1:** Heat production and heat dissipation at rest and during increasing cycle ergometry (from Leyk et al. (2019), page 538)

The increase in heat output is primarily achieved via 2 mechanisms:

- *due to the **increased sweat production** (already mentioned above)*  
Heat workers (e.g. in mining) lose 10-15 l of sweat per day. In sports (e.g. endurance disciplines) it is about 1-2 l of sweat per hour. The maximum rate of perspiration is around 4 l per hour, which, however, cannot be maintained for any length of time.
- *through **increased skin circulation**, which is particularly effective for the extremities from a thermoregulatory point of view.* Here, due to the larger surface-to-volume ratio, heat is physically released very well. The increases in blood flow are considerable. Hand circulation, for example, is said to be able to be increased by a factor of 30, with fingers even by a factor of 600.

A rise in core body temperature leads to increased blood flow to the skin to release heat. However, this means that less blood is available for the working muscles and internal organs. This also explains the performance reductions under heat stress.

## **b) Factors influencing heat tolerance**

People tolerate heat stress differently. For example, there are large individual variations in sweat production. Children and adolescents are more susceptible than adults. Despite gender-related differences (women with stronger subcutaneous fat tissue, menstruation-related shift in core body temperature, etc.), the thermal stress tolerance of women and men seems to be similar. The training condition also influences heat tolerance: trained people start sweating earlier, can increase skin temperature more than untrained people and react with lower increases in heart rate and core body temperature.

People can adapt surprisingly well to prolonged heat stress. Heat acclimatisation is therefore one of the most important physiological adaptation reactions, although this can vary considerably from person to person. 8-10 acclimatisation days should be sufficient. However, there are also shorter periods (4-7 days). Complete acclimatisation takes place within 4 weeks. The 3 classic signs of heat acclimatisation are lower heart rates, lower core body temperatures and higher sweat rates. Athletes can prepare for heat stress in hot climates by training (e.g. endurance runs in tracksuits): The higher core body temperature and increased sweating lead to better and faster acclimatisation.

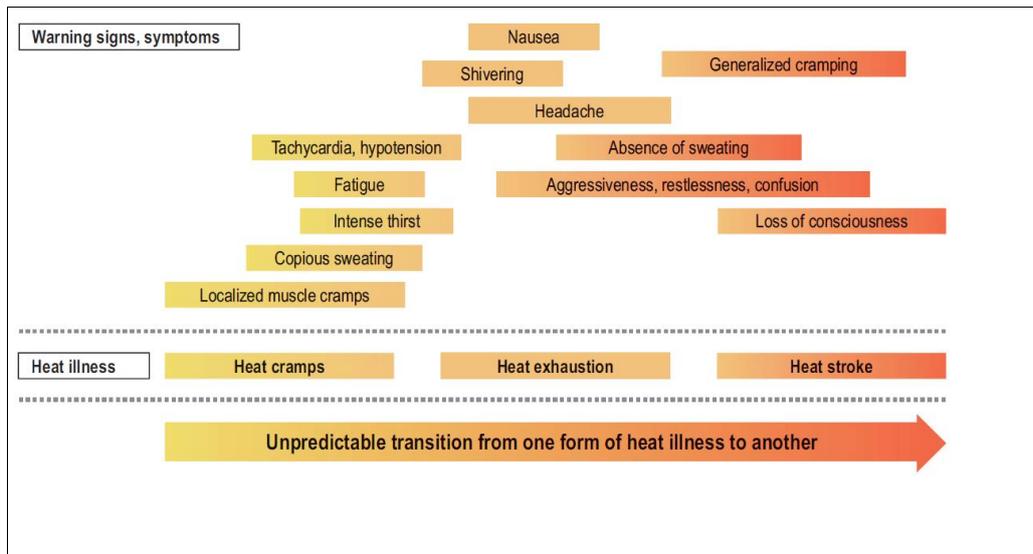
It should be noted, however, that acclimatisation is not permanent, but is lost quickly: if exposure to heat is interrupted for one week, a 50% loss of acclimatisation can be expected, and after two further weeks, a 100% loss of acclimatisation. Longer stays in strongly cooled rooms can consequently negatively influence acclimatisation adjustments.

However, it must be noted that elite athletes, such as 3x3 basketball players, cannot always acclimatise properly due to the event calendar, travel schedules and other commitments. In addition to short stays in the respective climate zones, acclimatization is further difficult as players spend significant time in air-conditioned planes, cars, hotels, etc. of which making acclimatization increasingly difficult.

It is hardly noticed or not known that heat tolerance can also vary considerably within a person. Acute infections, dehydration, electrolyte losses, medication, insufficient acclimatisation can lead to heat stress suddenly being less well tolerated even by competitive athletes.

## **c) Recognising & responding correctly to heat illness**

Sport under heat conditions can not only lead to extreme drops in performance, but very quickly to dangerous health crises. As described above, the muscular work leads to a strong heat production in the organism. In the endurance range, rectal temperatures of over 41° C have been measured. In addition to the excessively high core body temperatures, there is also a considerable loss of fluids and electrolytes due to exertion. Particularly in high-performance sports, where people regularly push themselves to the limit, the risk of severe heat-related incidents increases considerably. In American football, heat stress-related deaths have occurred time and again. In tennis (as in 2019 at the Grand Slam tournament in Melbourne) or in football (at the World Cup in Brazil in 2014), cool-down breaks have been introduced.



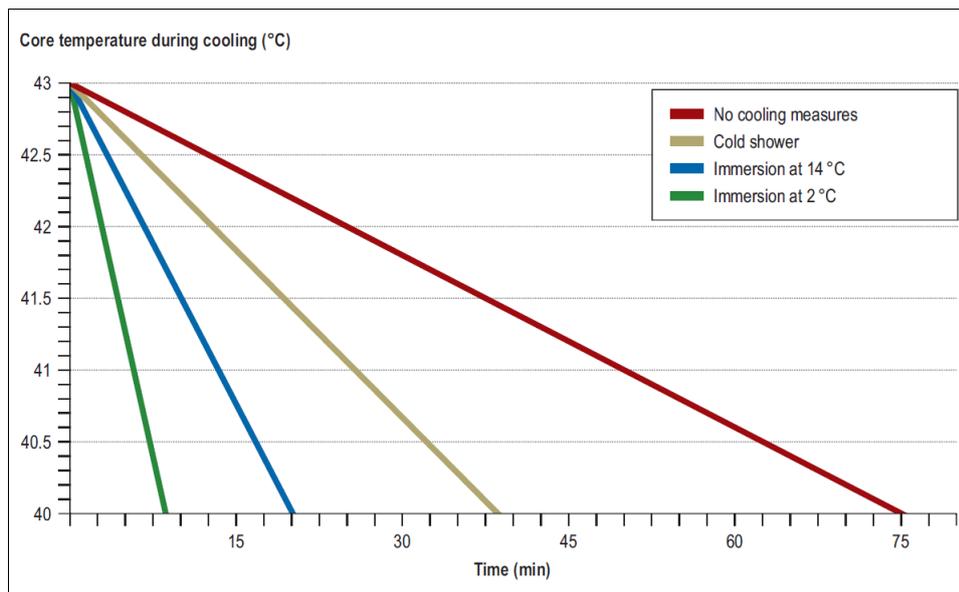
**Fig. 2:** Symptoms of heat illness which may not appear in any given order. Moreover, not all symptoms even may appear. The different forms of heat illness can suddenly develop without any warning (from Leyk et al. (2019), page 540)

Heat illnesses include sunstroke, heat cramp, heat exhaustion and life-threatening heat stroke. Direct exposure to the sun can lead to sunstroke. This mainly affects the head and brain. It can lead to dizziness, restlessness, headaches, nausea, possibly with vomiting, and unconsciousness. Painful heat cramps are also mostly a local phenomenon and affect the working muscles (e.g. calf cramps in football, basketball etc. or the hand/forearm muscles in tennis). There is often no severe overheating of the body (yet).

Typical of heat exhaustion are large fluid and electrolyte losses, weakness or exhaustion, rapid pulse, drop in blood pressure, dizziness, staggering, blackening of the eyes, headache, nausea, muscle cramps, possible collapse and unconsciousness. The body is overheated. Immediate de-warming must be initiated (move to the shade, cool, hydrate) and medical help must be sought. Core body temperatures above 40°C can trigger various pathophysiological processes that can end in multi-organ failure and heat stroke.

The particular danger of heat-related incidents is that a life-threatening heat stroke can develop abruptly from the various heat-related illnesses (Fig. 2). This can only be controlled if the core body temperature can be reduced to below 40° C within 30 minutes ("golden half hour"). Missed time cannot be made up: Failure to recognise heat stroke or delayed initiation of therapy leads to a significant increase in morbidity and mortality.

For ethical reasons and due to the duty of care, effective preventive measures are therefore essential during competitions under heat conditions.



**Fig. 3:** Time changes in core temperature. Differences in immersion at 2°C, at 14°C, cold shower and no cooling measures (from Leyk et al. (2019), page 542). Note that the only causal therapy for heat stroke is to reduce core temperature below 40°C within 30 minutes ("golden half hour").

#### d) Effective prevention & emergency treatment

It is undisputed that 3x3 outdoor basketball under heat conditions - despite the net playing time of only 10 minutes - considerably increases the risk of medically relevant heat-related illnesses. This is especially true when top teams have to play 2 games within only a few hours and these take place at hot times of the day. Also because the teams are not allowed to have a coach or doctor on the bench, effective preventive measures and, in case of emergency, effective immediate measures must be provided by the organisers (to achieve the "golden-half-hour" rule).

Before commenting on whether a sunshade/canopy should be compulsory at FIBA 3x3 outdoor basketball events, the crucial issue of reacting correctly in an emergency is addressed once again:

As already stated above, the immediate start of efficient cooling measures is the only causal therapeutic intervention. Sick persons must be quickly brought into a cool environment. The quickest way to reduce the temperature is to immerse the entire body in ice water. Less effective are immersions in cool water, cold packs, cold showers, etc. (Fig. 3). Water-filled bathtubs are used as a prophylactic measure during long-distance runs. Warming down should be continued closely with checks on core body temperature (and other vital signs) only until a core body temperature of 38-39° Celsius is reached. This can prevent "afterdrop phenomena".

The question of obligatory sun protection or canopies at FIBA 3x3 outdoor basketball events will first be addressed in terms of practical implementation and potential (visual) obstructions. There are mobile elements available that can be stretched and rolled up again within a few minutes using rolling mechanisms. Such systems are used, for example, in gastronomy, public places and event venues. The awnings can be installed in such a way that TV transmissions and the view of spectators are not obstructed.

The shading of the court leads to a considerable reduction of heat radiation and a significant reduction of the heat stress of the basketball players. The enormous effect of direct heat radiation is clearly illustrated by the example of hot car bodies standing in the sun. Again and again, there are pictures of skiers sitting in the sun with their upper body exposed at temperatures around zero. This is possible

because of the strong heat radiation that not only hits the body directly. As an additional heat source, there is also heat radiation from the ground as well as reflection of solar radiation by the ground.

### e) Conclusions associated to exertional heat stress

In conclusion, the above findings about heat stress and health risk, it is noted that:

- Shading the 3x3 outdoor basketball court with awnings or other roofing can achieve significant reductions in heat stress, performances losses and health risks.
- For ethical reasons, there should be a mandatory sunshade or canopy at elite 3x3 outdoor basketball events as shading is considered a key preventive measure to mitigate the risk of dangerous exertional heat stress.
- When it rains and the playing surface is wet, these could also significantly reduce the risk of injury to basketball players.

## 4. Impact of heat on player performance

In addition to the potential health risks caused by performing physical activities under extreme heat and heat radiation, this section explores the impact of direct solar/ heat radiation on player performance:

### **Solar Radiation: Fatigue, Recovery Time, etc.**

Solar radiation can significantly impact the athlete's fatigue level and recovery time. Long-term exposure to the sun can cause skin damage and lead to dehydration, which can contribute to increased fatigue levels. Dehydration can also negatively impact the body's thermoregulation, leading to increased internal body temperature, which can increase the risk of heat-related illnesses.

Furthermore, sun exposure can impair post-exercise recovery, thereby affecting subsequent performance. A canopy would provide shade and protection against direct sun exposure, helping to reduce dehydration risks, decrease fatigue, and potentially enhance recovery times.

### **Impact of Heat on Physical Performance Factors**

Heat stress can have several impacts on physical performance. Primarily, it can lead to reduced endurance, muscle strength, speed, agility, and reaction time due to increased body temperature.

Heat can also impact cognitive functions, affecting decision-making, concentration, and coordination, which are critical to 3x3 basketball performance.

A canopy can play a significant role in mitigating the impacts of heat stress. By providing shade, a canopy can reduce the ambient temperature, thereby lowering the risk of hyperthermia and minimizing the negative impacts on physical performance.

In conclusion, implementing a canopy could help maintain physical performance levels, reduce fatigue, improve recovery times, and ultimately contribute to the safety and wellbeing of 3x3 basketball athletes.

## 5. The relevance of shading/ roofs in injury prevention & safe player environment

Research supports that a canopy in an outdoor sporting environment, like 3x3 basketball, could play a vital role in injury prevention and the creation of a safe player environment. Canopies can contribute to minimizing the risk of slips, falls, and other injuries related to environmental conditions.

Heat stress can increase the likelihood of injuries by promoting fatigue, decreasing reaction time, and impairing judgement and coordination. A canopy can provide shade and reduce the heat stress on players, thereby reducing the likelihood of these risk factors.

### **Injury Risk and Humidity (following rain): Moist Playing Surface**

Following rain, the playing surface can become slick and slippery, significantly increasing the risk of slips, falls, and associated injuries. A canopy can provide protection against rainfall directly onto the court, maintaining (or accelerating the process back to) the integrity of the playing surface and by doing so reducing the objective injury risk. Especially in the prevention of basketball typical injuries (caused by high speed, sudden changes in direction, jumping and pivoting) a dry playing surface and the mental reassurance for athletes that the roofing protects from environmental factors is thought to be very important.

### **Injury Risk and Visual Impairments: Sun Blinding**

During outdoor play, players can be affected by the sun's glare, impairing their vision and potentially increasing the risk of collision or misjudgement of ball trajectory. Direct sun exposure can also lead to sunburn and longer-term eye damage, like cataracts.

A canopy can shield players from direct sun exposure, improving their visual acuity and reducing the risk of such injuries.

In conclusion, a canopy's implementation can play a crucial role in safeguarding player health and welfare by creating a safe environment, preventing injuries, and ensuring optimum playing conditions. As such, it is strongly recommended for consideration by 3x3 basketball event organisers.

## 6. Conclusion

This last section, aims to summarize the research findings and link them to the initial research hypothesis, which reads as follows:

*"A canopy is a necessity in elite 3x3 to protect athletes from extreme environmental conditions (heat, sun, rain). 3x3 is a high intensity physical exercise and no shading may lead to:*

- *higher level of physical stress;*
- *Risk of heat stress (heat stroke, heat exhaustion, etc.);*
- *Lower performance; and*
- *Higher risk of injury."*

Comparing the research findings to the hypothesis, it can be concluded:

- The findings on "exertional heat stress" demonstrate that extreme weather conditions, such as heat and direct sun radiation, dramatically increase heat stress on elite 3x3 players and subsequently, increases the risk for health hazards. Roofing and providing shade for the playing court is considered one of the primary and most effective preventive measures as it

can decrease temperature and eliminates direct sun radiation which is a crucial factor for heat stress. Roofing as preventive measure should be combined with additional safety measures as well as the capacity to act quickly in case of medical emergencies.

- Furthermore, as it relates to the “impact of heat on player performance”, research suggests that heat stress is not only a health risk, but also impacts players’ immediate physical performance. As heat stress may extend recovery times it may even impact player performance in the mid- and long-term. Shading eliminates direct sun radiation and can reduce the ambient temperature, thereby lowering the risk of hyperthermia and minimizing the negative impacts on physical performance.
- Lastly, “the relevance of shading/ roofs in injury prevention & safe player environment” explores the benefits of canopies related to additional environmental factors (besides heat) – most importantly: rain and sun light. In the event of precipitation, the risk of injury from wet playing surfaces can be reduced by providing roofing solutions. Besides keeping the playing surface dry, the roof can provide mental stability for the athletes in such a context. Furthermore, it was established that a canopy can protect from direct sun glare, which has the potential to impair player vision and potentially increasing the risk of collision or misjudgement of ball trajectory.

In conclusion, the research hypothesis is confirmed and concluded that roofing (i.e. through a canopy) is an efficient preventive measure to ensure a safe playing environment and reduce the risk of exertional heat stress in elite 3x3 players.

Providing roofing in extreme heat conditions is a necessity to ensure an integer environment for players. Roofing shall be combined with additional preventive measures and best practices (for event related medical services) to make 3x3 events successful and safe.

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