11 Tennis in the Heat

Michael F. Bergeron

11.1 Introduction

The heat is a formidable opponent for tennis players at all levels of competition. Extensive sweating prompting measurable body water and electrolyte deficits is noticeably prevalent during extended play in hot and/or humid weather. As environmental conditions become more challenging, even the fittest of players are recognizably affected, as a concomitant level of thermal and cardiovascular strain increasingly challenges one's physiology, perception of effort, and on-court well-being and performance. This is visibly evident in recreational tennis, but the challenge is typically greatest in tournament competition where the intensity of play is high and persistent, and the duration of each match often extends to several hours or more [1–4]. Even with just one match a day, repeated daily exposure to the demanding environmental conditions can progressively take its toll as players advance through an increasingly difficult draw. However, the challenge of cumulative tennis and heat exposure is particularly notable and difficult when players are required to compete more than once on the same day across successive days in a single event.

This chapter highlights the relevant evidence and perspective on challenges facing junior and adult tennis players in the heat specific to characteristic thermoregulatory responses. This is followed by practical considerations and steps in mitigating undue on-court thermal strain and clinical risk. The last section emphasizes the need for more inclusive real-world scenarios in research and the informed utility of technology and advanced analytics. More detailed explanations and supporting evidence are presented in the earlier chapters, regarding the physiological mechanisms and consequent changes in related systems functionality that are

M. F. Bergeron (✉)
SIVOTEC Analytics, Boca Raton, FL, USA
e-mail: mbergeron@sivotecanalytics.com

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fundamental to these responses and challenges confronting tennis players in the heat. Thorough discussion of exertional heat illness is also covered earlier, as well as applicable recommended prevention strategies and clinical management.

11.2 Thermoregulatory Responses and Challenges in Tennis

11.2.1 Sweat Loss During Tennis

Sweat loss during tennis in the heat can be noticeably extensive. While the format of tennis competition provides regular opportunities to consume fluids, sufficiently effective rehydration during and after play often involves more than simply ample fluid volume intake. Notably, on-court sweat sodium and chloride losses can be substantial, even for players who are well-acclimatized to the heat [5, 6]. Accordingly, deliberate additional salt intake (by way of daily fluid and/or food consumption) is often warranted to ensure complete rehydration and optimal body water retention and distribution in all fluid compartments [7–11]. As with body water loss via sweating, sweat sodium and chloride loss rates are highly variable and must be addressed specific to individual needs [5–7, 12].

11.2.1.1 Junior Tennis

With increasing environmental heat stress (air temperature, humidity, and solar radiation) and intensity and duration of play, young adolescent tennis players are readily capable of on-court sweating rates that are near or exceed 1.0 L/h during practice [13] and tournament singles and doubles competition [14]. Parallel to physical and physiological development and maturation, an increasingly greater muscle mass produces more heat; thus, there is a greater need for evaporative cooling. And with more mature sweat glands and a larger capacity for sweat production [15], sweating rate in older adolescents during intense practice and competitive play in challenging hot conditions can often reach 2.5 L/h or more [5, 6].

11.2.1.2 Adult Tennis

Comparable to older adolescents, and often to a much greater extent, on-court sweating rates in adult tennis players can be extensive during intense practice and competitive play [6, 16–21]. Among the still limited reported examples of on-court sweating rates during tennis in adults, Bergeron et al. [16] evaluated male and female tennis players from two Division I university tennis teams during three successive days of competitive round-robin play in the heat; Périard et al. [20, 21] monitored heat non-acclimatized men during two simulated matches; Hornery et al. [17] examined male professional tennis players during international tournament competition; and Tippet et al. [19] examined professional women players during outdoor tournament play in similar hot environmental conditions. While on-court sweating rate was extensive in many instances (i.e., 2.0 L or more per hour), post-play body weight deficits were only modest (generally around 1% or a little more/less).

11.2.2 Heat Strain

As ongoing metabolic heat production and storage continues, a tennis player's body core temperature can be expected to progressively increase as play persists. This signature of evolving heat strain is especially intensified during a hard practice session or competitive intense match in the heat. Moreover, the repeated complex, intermittent activity patterns, with varying workloads and short recovery periods between points, that are characteristic of tennis can further exacerbate on-court thermal strain and related clinical risk [22]. Notably, however, reports of players (at any level of competition) incurring exertional heatstroke on-court or immediately post-play are rare, whereas heat exhaustion is likely far more common in tennis when collectively prompted by the aggregate of extended strenuous play, a measurable total body water and energy deficit, and central fatigue [23, 24].

Measuring body core and skin temperature and other relevant metrics during tennis competition is not trivial; however, advances in sensor and integrated platform technologies and methods have made it more feasible [25–28]. Nonetheless, the logistics and hesitancy by elite players to alter their routines during sanctioned competitive play are practical barriers. Accordingly, researchers have more commonly utilized simulated tennis protocols to gain helpful insights to expected exertional heat strain incurred on-court during competition. Visible indications of thermal strain in players are routinely observed during hot-weather competition; and more detailed emerging perspective on heat-related court calls and post-match clinical consults has been described at select professional events [3, 4]. However, the specific extent and confirmed prevalence of undue body core temperature and exertional heat illness, for example, as well as a clear appreciation of modifiable contributing factors, across a practical range of heat and humidity are largely not well-described in sanctioned tournament play.

11.2.2.1 Junior Tennis

Bergeron et al. [13] examined thermal strain in highly skilled, fit junior tennis players (on average, 15 years old) during intense on-court training (rallying using a variety of strokes and patterns and playing competitive points) in a very warm environment (WBGT: 26.6 °C in the water trial; 26.3 °C in the carbohydrate-electrolyte commercial sport drink trial). Their findings did not reveal an association of pre-practice hydration status (as indicated by urine specific gravity) with body core temperature during the 2-h practice sessions. However, a lower mean core temperature was observed during the randomized carbohydrate-electrolyte drink trial (38.0 ± 0.2 °C) compared to the water trial (38.2 ± 0.3 °C). Notably, while body core temperature approached or reached 39 °C for some players, none of these young athletes had any visible indications of excessive thermal strain.

To examine thermal strain in junior tennis players during actual sanctioned tournament competition, Bergeron et al. [14] observed eight elite-level young boys during the first round of singles and doubles play in a United States Tennis Association 14 s age group national championships event during early August. In contrast to the 2-h practice sessions described above, pre-play hydration status (urine specific gravity) was increasingly associated with on-court body core temperature (final reading: 38.7 ± 0.3 °C) during singles play as the matches advanced (WBGT: mean 29.6 °C; range 28.5–30.1 °C). This underscores the contrast of metabolic heat production and storage during meaningful competition versus practice or simulated competition. These elite players characteristically still maintained a strong effort and very high intensity, though it was only the first round of competition. This study also highlighted how even doubles play in junior tournament-level tennis can elicit appreciable thermal strain in hot conditions (WBGT: 31.3 °C).

11.2.2.2 Changes Across Adolescence

The long-standing belief that youth athletes have greater difficulty tolerating sports or other physical activity in the heat because of a purported biological maturation-related disadvantage has been distinctly countered by more current research and position stands [24, 29, 30]. Cardiovascular capacity and thermoregulation are generally adequate, if hydration is amply maintained [31–34]. However, there are progressively greater challenges during vigorous tennis in the heat for boys and girls as they physically and physiologically develop and mature, more heat is produced during play from a greater muscle mass, and more mature sweat glands yield increased sweat production [15]. This can result in greater on-court thermal loads and an increase in sweat fluid and electrolyte (primarily sodium) losses. Accordingly, total body water and exchangeable sodium deficits from extensive sweating can be comparatively more substantial in mid- to late-teen tennis players. Moreover, longer and physically demanding workouts and matches are characteristic of more physically developed, fit, and skilled older adolescent players. Thus, there is a potential for greater levels of muscle damage and various physiological carry-over effects that could further increase thermal strain and other clinical risks during the next training session or match [35].

11.2.2.3 Adult Tennis

Périard et al. [21] reported only moderate thermal strain in the heat, as did Hornery et al. [17] with similar peak body core temperatures (38.5–39.4 °C) reached during hard and clay court professional tournament play. And Tippet et al. [19] also observed only moderately high mean (38.7 ± 0.20 °C) and peak (39.1 ± 0.3 °C) body core temperatures in female professional tennis players throughout match play. However, even without conditions prompting excessive thermal strain, Périard et al. [20] found that on-court body core temperature was reduced during the early stages of play when better pre-play hydration achieved with specified individualized water volume intake and a target sodium content.

11.2.3 Repeated Same-Day and Successive-Day Match Play

Arguably the most recognized challenge for a tennis player to maintain hydration, minimize on-court thermal strain, and perform optimally is during a hot-weather tournament when multiple singles matches are played on the same day and the scheduled rest and recovery periods between contests are inappropriately brief. This is particularly characteristic of junior tennis, especially during tournaments at the local and regional levels. Though, in many same-day scenarios or across successive days with older adolescent players *and* adults, on-court and consequent daily accumulated body water and sodium losses can be significant from repeated extensive sweating. Thus, adequately rehydrating and minimizing day-to-day between-match total body water and exchangeable sodium deficits can be particularly difficult for certain individuals [6, 12].

The recognized impact of previous competition-related physical activity and heat exposure on subsequent same-day physiological strain and performance in tennis is very clear to those participating and closely observing. In contrast, this undue burden is evidently not fully appreciated by many event organizers. Moreover, the repeated-bout effect in tennis has not been adequately empirically examined. The only reported measured performance impact of prior same-day tennis-heat exposure (degree-minutes) during official competitive match play was that assessed by Coyle [36] with boys during a 14's national championships event over a 7-year period. However, field and laboratory studies on repeated-bout non-tennis exercise in adults and youth clearly demonstrate a negative impact on the next bout of activity, because of various physiological "carry-over" effects from previous same-day strenuous physical activity and heat exposure. Even with ample hydration and body core temperature returning to baseline before starting a second bout of exercise, a marked carry-over effect on physiological and perceptual strain remained [37–42]. In more stressful environmental conditions and a more typical uncontrolled real-world setting, following a long intense competitive tennis match and measurably incomplete rehydration and body cooling before going on court again, an expected greater impact would be likely. Nevertheless, these limited relevant findings provide important insight that should help guide more practically appropriate tournament scheduling, as heat and humidity and the concomitant threat to health and performance increase.

11.2.4 Clinical Conditions, Medications, and Caffeine

Standard precautions should be taken with tennis players who are currently (or were recently) ill, which may dictate significantly reducing the practice and/or playing load in the heat. A recent bout of exertional heat illness may be a good reason to do the same. While the conservative approach minimally dictates a deliberate focus on implementing additional offsetting measures specific to readily modifiable risk factors in both instances, following best practices may warrant avoiding play and practice altogether.

Using certain medications (e.g., a non-steroidal anti-inflammatory drug, dopamine reuptake inhibitor to treat attention-deficit/hyperactivity disorder, or diuretic) should be explicitly discussed with one's own primary healthcare provider, in advance of training or competing in a hot environment, especially if there is a history of excessive thermal strain or exertional heat illness [23, 29, 43, 44]. Caffeine consumption, despite its routine use by many players [45] and demonstrated ergogenic effects [46, 47], is often discouraged in tennis, especially during hot-weather training and competition. However, caffeine does not appear to be appreciably thermogenic or interfere with heat dissipation during exercise-heat stress; thus, concerns over measurable effects of caffeine intake on thermoregulation, fluid-electrolyte balance, and exercise-heat tolerance do not appear to be warranted [48, 49]. Accordingly, up to moderate caffeine consumption prior to play is not likely to augment thermal strain and exertional heat illness risk or impede or lessen on-court performance.

11.3 Mitigating Heat Strain and Clinical Risk

11.3.1 What Can Tennis Players, Coaches, and Administrators Do?

Any time junior and adult tennis players compete or train in the heat, the potential risk of incurring a significant total body water deficit, undue thermal strain, and/or exertional heat illness should be appreciated by everyone involved. This is especially the case when participating in multiple same-day matches or practice sessions over several days or more in a row. As noted earlier, players should avoid or significantly limit practice, training, and competition in hot and/or humid conditions, if they are currently ill or are recovering from an illness, especially those illnesses involving gastrointestinal distress (e.g., vomiting, diarrhea) and/or fever [23, 29]. These and other individualized appropriate modifications to tennis practice and training are essential for affected players, especially in the heat.

Administratively, for any tennis tournament where warm-to-hot environmental conditions are anticipated, written protocols following "best practices" standard of care should be in place and practiced, and trained personnel with readily available facilities should be on-site, for effectively treating all forms of exertional heat illness [23]. An increasing need for medical personnel to be promptly responsive to an escalating frequency of heat-related on-court calls and post-match clinical consults and treatments should be anticipated as environmental conditions become more challenging [3, 4]. Moreover, all tennis players (and those coaches and administrators overseeing training and competition in the heat) should also focus on other readily modifiable risk factors beyond just hydration management, such as heat acclimatization, cooling strategies, and scheduling of play [20, 29, 50–53].

Fundamental factors contributing to exertional heat illness risk and primary practical offsetting measures during tournament tennis in the heat are highlighted in Table 11.1.

Table 11.1 Fundamental factors contributing to exertional heat illness (EHI) risk and primary practical offsetting measures during tournament tennis in the heat

EHI risk factors	Preventive or offsetting measures
• A hot and/or humid climate (including no or very little breeze and cloud cover) • Players who are traveling and likely not sufficiently acclimatized to playing in the heat/humidity • Extensive competitive play or training in the immediate period leading up to the event • Players who inherently sweat considerably • Long matches • Multiple same-day matches—notable increased risk after the first match owing to carry-over effects • Little or no on-court shade	• Ensure adequate daily water and sodium intake based on *individual* on-court sweat losses – Prior to each match, drink appropriate fluids regularly throughout the day – During play, consume fluid regularly to appropriately offset body water and sodium losses from sweating – After play, drink *up to* ~120% of any remaining body water deficit (indicated by a change in body weight) over the rest of the day and before the next day's match – Consume additional sodium daily via foods and fluids, especially when sweating extensively and repeatedly • Minimize match warm-up time and unnecessary heat exposure • Consider on-court and between-match cooling strategies • Administrators should ensure – Adequate (i.e., extended) rest and recovery time between same-day matches – Close monitoring of (and prompt response to) participants for signs and symptoms of developing heat illness – Readily available (on-site) trained personnel and facilities for effectively treating exertional heat illness

Every player (and, as applicable, reinforced by respective responsible coaches and/or parents) always has the responsibility to begin play healthy, well-hydrated, well-nourished, well-rested, adequately fit, and otherwise prepared for the demands of competition (accordingly, these potential risk factors are not listed). These recommendations apply as well to practice in the same conditions

11.3.2 Pre-Play Preparation

Players and coaches should follow a graduated introduction and exposure to practice and play in a hot and/or humid environment, while progressing similarly with the accompanying intensity and duration of practice/training and competition. Progressive acclimatization to the environment, activity, and physiological demands is essential to minimize on-court performance decrements and the concomitant risk of incurring exertional heat illness. This is not always practically feasible when traveling between locations to an event in a more stressful (greater heat and/or humidity) environment. However, even arriving just an additional 2–3 days early to acclimatize to the new weather conditions can measurably help [54].

Players, coaches, and parents must also be prepared to appropriately adjust for changing weather conditions, recognizing that tolerance to physical activity decreases and exertional heat illness risk increases, as the heat and/or humidity rise [24, 29, 53]. For practice, the duration and overall intensity of activities and each session should be eased, and the frequency and duration of breaks should be increased, to maintain safety, attention, and performance. During competitive scenarios, duration of pre-match warm-ups in hot and/or humid weather should be minimized. To further minimize on-court cardiovascular and thermal strain, all players should be well-hydrated and well-nourished prior to going on court to compete [20, 55–57].

11.3.3 During Play

Players should drink appropriate and appealing fluids regularly on each changeover during every match [5, 6, 13, 14, 16, 43]. While optimal fluid intake (volume and beverage characteristics) during tennis match play is indeed situation- and individual-specific, drinking to thirst is not always adequate to sufficiently maintain hydration status or optimal performance, especially for those with a high sweating rate during extended play [58]. In contrast to earlier findings with non-tennis youth [59, 60], unflavored water has more recently been shown to be equally effective as a carbohydrate-electrolyte sports drink (CHO-E) in minimizing total body water deficits in physically active young girls during intermittent exercise in the heat [61]. The same was demonstrated with high-level, fit junior tennis players during intense on-court training in outdoor hot conditions [13]. However, many older adolescent and adult players who sweat extensively may benefit from an individualized level of regular concomitant sodium intake on-court during breaks. This will enhance rehydration and partially offset a rapidly evolving sweat-induced exchangeable sodium deficit [5–7, 16].

Readily available access to and ample regular intake of appropriate beverages is a priority. In addition, taking advantage of shaded space and a variety of short-term cooling practices (e.g., fans, umbrellas, iced and cold damp towels), along with the full allotted time on changeovers and between points, can improve perceptual and physiological strain [1, 21, 62, 63]. If it is within the scope of viable options, players can select to construct shorter points by modifying playing style as a player's capability allows, thus reducing overall exertion and metabolic heat production and storage to some extent [64]. Nonetheless, all tennis players should be closely monitored in the heat, and a prompt and appropriate response, including immediately stopping participation and seeking appropriate medical attention and treatment, should be implemented at the earliest signs of developing exertional heat illness.

11.3.4 Post-Play Recovery

Effective post-play rehydration involves more than simply ample water intake. Even with frequent breaks and opportunities to rehydrate during practice or with regularly consuming water or other beverages on each changeover during a long match, a post-play body water and/or exchangeable sodium deficit can be significant. Accordingly, a more deliberate individualized rehydration plan between sessions and matches is often essential. Concomitant with appropriate energy and other nutrient intake, electrolytes (especially sodium) need to be sufficiently consumed as well to offset potentially extensive sweat-related electrolyte losses and to better retain and distribute ingested water [5, 7, 12, 14, 16]. For same-day repeated matches, players should stay in the shade and/or airconditioned places to rest and recover. It is also fitting to minimize or eliminate (when the between-match time is brief) any additional pre-match warm-up period.

11.3.5 Evidence-Informed Tennis in the Heat Guidelines

The applicable knowledge base, awareness, and concern for player safety and well-being in the heat have noticeably improved in the past decade or so. Unfortunately, most current hot-weather preparation, on-court, recovery, and scheduling recommendations and guidelines promoted by tennis governing bodies for effectively managing hydration, reducing thermal strain, optimizing performance, and minimizing exertional heat illness risk on-court are not sufficiently sport-specific and evidence-based. For example, practical on-court cooling methods [1, 62, 63] need to be more closely and comprehensively assessed in tennis; and various established guidelines for stoppage or modifying play in the heat should be more thoroughly and objectively scrutinized [3, 4, 65]. Tippet et al. [19] specifically examined of the effectiveness of the Women's Tennis Association Extreme Weather Conditions Rule in reducing thermal strain. This rule (in place since 1992) currently allows for a break in play between the second and third sets of the match when the on-site wet-bulb globe temperature (WBGT) meets or exceeds 30.1 °C [65]. After the permitted 10-min break, body core temperature decreased by 0.25 (0.20) °C. However, core temperature remained slightly higher than it was at the start of the previous second set. By the end of play, peak thermal strain was similar as observed at the end of the second set. But without many more similar observations in competitive (including men's) tennis, as well as a comparison to extended-set vs 3-set scenarios in extreme weather (as defined by this rule) where players do not take the between-set break, full appreciation of the extreme weather rule effectiveness on player well-being in reducing thermal strain would be premature.

Recognizing the insufficient tennis-specific on-court and recovery data and knowledge to better guide players and coaches, certain recommendations of best practices should still be emphasized to minimize exertional heat illness risk and improve player safety, well-being, and on-court performance. This is particularly relevant with the notably greater exertional heat illness risk and potential performance challenges resulting from multiple competitive matches in hot weather on the same day. Tennis governing bodies and tournament administrators should accordingly provide longer rest and recovery periods between same-day matches as environmental heat stress increases. And while coaches and event administrators should always provide adequate between-session/match recovery time, especially in the heat, a greater accommodation for recovery should be anticipated and liberally applied, as young tennis players get older, and train and compete repeatedly and at a higher level.

11.3.6 Players with Disabilities: Wheelchair Tennis

Wheelchair tennis continues to grow in participation and popularity, reinforced and showcased by the Paralympics and International Tennis Federation (ITF) through their widespread schedule of global events, development funds and programs, and high-profile ambassadors [66]. Not surprisingly, wheelchair competitors are exposed to the same extreme heat conditions and related health risks and performance barriers as able-bodied players. Accordingly, many of the same risk mitigation strategies (heat acclimatization, reduced pre-match heat exposure, modification of play style, hydration, etc.) as with able-bodied players are appropriate and effective. However, there are also numerous additional inherent modulating factors and related clinical risks with spinal cord injury (SCI), based on the variance of spinal lesion level and consequent degree of physiological impairment. For example, this population demonstrates proportionate impaired thermoregulatory function and consequent increase in body core temperature and heat storage during vigorous exercise in the heat, compared to able-bodied peers [67]. There is also greater heat retention during exercise recovery. Thus, traditional between-game cooling strategies on changeovers during wheelchair tennis are not as effective. The aggregate potential effect is an intrinsic higher risk (proportional to the injury level) of developing exertional heat illnesses during tennis competition in the heat [68]. While the ITF provides guidelines to allow for a 10-min break between second and third sets when the WBGT meets or exceeds 30.1 °C or suspension of play (32.2 °C) in extreme weather conditions [69], research to determine more evidence-informed heat safety thresholds and guidelines specific to wheelchair tennis is prominently lacking.

11.4 Future Directions

The published empirical evidence of heat-related physiological responses and metrics in youth and adult tennis players during unrestricted sanctioned competition is very limited. As a result, this narrow selection of observations does not fully reveal or represent the full scope of practical hydration and thermal strain challenges, exertional heat illness risks, and barriers to performance that many tennis players face when competing in the heat. Accordingly, currently established general recommendations for maintaining hydration and minimizing on-court thermal strain and exertional heat illness risk in youth and adults [24, 29, 70, 71] should be recognized as having a limited field-supported, evidence base specific to tennis.

11.4.1 Real-World Scenarios in Tennis

Much more research needs to be done to better appreciate the full scope and extent of the physiological demands and hydration and thermal strain challenges confronting junior and adult tennis players in various environments, competition formats, and venues. New investigations should include profiling players during longer, more intense, 3-set to 5-set matches played in the afternoon during later rounds of sanctioned tournaments. This is where the risk is likely to be appreciably greater for significant body water deficits and other physiological carry-over effects from previous rounds of play, as well as undue thermal strain. Reported incidents of heat-related court calls, requests for cooling devices, and post-play medical consults across environmental heat stress zones at the Australian Open have, however, provided some important preliminary practical insights to the escalating parallel heat strain incurred by players during competitive elite tennis [3, 4].

Examining the impact of environmental heat and thermal strain on hyperthermic fatigue, neuromuscular function, and musculoskeletal or other injury risk [72–74] should also be clinical, player management, and research priorities. These effects should be specifically profiled in response to extended and repeated bouts of intense tennis training and sanctioned competition across multiple successive days and weeks, as this reflects practical tennis schedules. Current perspective based on selected discrete test measures during and after only simulated match play bouts [20, 75, 76] in the heat is insufficient. Moreover, current risk-reduction strategies for pre-play, on-court, and between-set cooling, enhanced hydration, and between-match recovery need to be better clarified and validated for practical efficacy in real-world scenarios with able-bodied and wheelchair tennis [77–82]. Research on the interacting effects of schedule, travel, and heat-acclimatization status of players on clinical risk and performance is also needed. Accordingly, it is premature to claim a full appreciation of the real-world challenges these athletes face during sanctioned competition.

11.4.2 Technology and Advanced Analytics in Tennis Heat Safety Research

The experimental setting (i.e., laboratory or on-court with simulated match play) often utilized in evaluating cardiovascular and thermal strain and other physiological responses during tennis in the heat has significant practical translation limitations. Many of the observations, conclusions, and purported applications are, in certain instances, too far removed from a more real-world competitive tennis context. Moreover, the physiological and psychological demands and individual responses of a tennis player’s complex biological system while on-court and during tournament play cannot be fully interpreted by evaluating only a minimal number of discrete measures. This is especially evident with measurements limited to only pre- and post-play, or when the players under observation are in a controlled setting detached from the natural environment of daily multiple stressors and other wide-ranging influencing factors. Also, generalized heat-safety guidelines based on environmental conditions alone do not adequately address the practical individual on-court or recovery differences and needs.

There has been a noticeable recent explosion of advanced technology for physiological monitoring in Sport, including a vast array of wearable and remote smart sensors for real-time data collection, supported by integrated platforms with advanced algorithms and analytics and practical easy user interface [25, 83, 84]. Efficiently and effectively collecting, managing, and analyzing massive amounts of structured and unstructured information from multiple disparate domains requiring high-performance computer systems is, moreover, no longer the limiting factor. Today, we have the capacity to address all the variables outlined in this chapter and other influencing factors in a widely inclusive, multi-domain, and real-world knowledgeable and innovative way. This is critical to developing and optimizing more effective and practical, evidence-based recommendations and guidelines for tennis players who are training and competing in the heat. Artificial intelligence-driven machine learning and advanced analytics can also help reveal what has been previously unachievable (or even conceived) in more precisely defining player response/risk signatures and patterns that will assist further in determining definitive evidence-informed heat safety guidelines and protocols. The collective effect of these new tools and approaches allows scientists to consider multiple applicable domains of information, much larger data sets, and many more relevant variables and influences. This will no doubt lead to developing valid new predictive models and applications that can better assist in anticipating clinical care needs, mitigating modifiable risk in advance, and clinical decision support [85, 86]. The compelling impact will be to practically and more optimally mitigate exertional heat illness risk while optimizing performance for all tennis-playing populations. Indeed, this timely approach will help to close the gap between research and practical acceptance and uptake of related heat safety recommendations and guidelines for tennis and all of Sport.

11.5 Key Points

- Sweating during tennis can be extensive, leading to significant total body water and exchangeable sodium deficits.
- Thermal strain can be significantly elevated during tennis; however, the inherent nature and format of tennis may be the principal mitigating factors in players incurring excessive body core temperature and loss of thermoregulatory control leading to exertional heatstroke.
- Much more real-world research of tennis competition is needed to fully appreciate thermoregulatory challenges confronting players training and competing in the heat, as well as to design the most practically efficacious, evidence-informed heat safety guidelines.

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