Journal of Athletic Training 2018;53(3):230–239
doi: 10.4085/1062-6050-138-16.35

www.natajournals.org

A Functional Return-to-Play Progression After Exertional Heat Stroke in a High School Football Player

Rebecca M. Lopez, PhD, ATC, CSCS*; Patrick Tanner, MS, ATC†; Sarah Irani, MD, FAAP, CAQSM‡; P. Patrick Mularoni, MD, FAAP, FACEP, CAQSM‡

*Department of Orthopaedics and Sports Medicine, University of South Florida, Tampa; †Orlando City Soccer Club, FL; ‡Division of Sports Medicine, Johns Hopkins All Children's Hospital, St Petersburg, FL

Objective: To present a functional return-to-play (RTP) progression after exertional heat stroke (EHS) in a 17-year-old high school football defensive end (height = 185 cm, mass = 145.5 kg).

Background: The patient had no pertinent medical history but moved to a warm climate several days before the EHS occurred. After completing an off-season conditioning test (14- × 110-yd [12.6- × 99.0-m] sprints) on a warm afternoon (temperature = approximately 34°C [93°F], relative humidity = 53%), the patient collapsed. An athletic trainer (AT) was called to the field, where he found the patient conscious but exhibiting central nervous system dysfunction. Emergency medical services were summoned and immediately transported the patient to the hospital.

Differential Diagnosis: Exertional heat stroke, heat exhaustion, exertional sickling, rhabdomyolysis, and cardiac arrhythmia.

Treatment: The patient was immediately transported to a hospital, where his oral temperature was 39.6°C (103.3°F). He was transferred to a children's hospital and treated for rhabdomyolysis, transaminitis, and renal failure. He was hospitalized for 11 days. After a physician's clearance once the laboratory results normalized, an RTP progression was completed. The protocol began with light activity and progressed over 3 weeks to full football practice. During activity, an AT monitored the patient's gastrointestinal temperature, heart rate, rating of perceived exertion, fluid consumption, and sweat losses.

Uniqueness: Documentation of RTP guidelines for young athletes is lacking. We used a protocol intended for the football setting to ensure the athlete was heat tolerant, had adequate physical fitness, and could safely RTP. Despite his EHS, he recovered fully, with no lasting effects, and successfully returned to compete in the final 5 games of the season.

Conclusions: Using a gradual RTP progression and close monitoring, a high school defensive end successfully returned to football practice and games after EHS. This case demonstrates the feasibility of implementing a safe RTP protocol after EHS and may serve as a guide to ATs working in the high school setting. This case also highlights the need for more research in this area.

Key Words: recovery, conditioning, heat illnesses

Key Points

- By using a gradual return-to-play progression, athletic trainers in the high school setting can safely return an athlete to sport participation after exertional heat stroke and physician clearance.
- Communication and teamwork among athletic trainers and other medical and athletic professionals is important for safely returning an athlete to participation after exertional heat stroke.

Exertional heat stroke (EHS) is the most severe type of exertional heat illness (EHI). In the past 2 decades, substantial advances have been made in research on and education in preventing, recognizing, and treating EHS. Many of these efforts have focused on predisposing factors for EHS, proper recognition via rectal thermometry, and adequate cooling via ice-water immersion before transport.[1–6] Preventing EHS and ensuring adequate medical coverage on the sidelines are also of paramount importance. In particular, researchers should focus on establishing better safety guidelines for offseason strength and conditioning sessions, including medical coverage at all conditioning sessions.[1,2] In addition, little is known about the functional progression and return to play (RTP) of an athlete after EHS. Recent position and roundtable consensus statements[4,7] have noted the lack of structured guidelines for RTP from EHS in the athletic setting.

Traditionally, the guidelines for RTP after EHS have consisted of general exercise recommendations or heat-tolerance testing.[7,8] The latter has been widely used in the military setting,[7,9,10] but its applicability in the athletic setting has not been elucidated. Furthermore, the equipment needed for heat-tolerance testing (ie, climatic chamber) may not be accessible in the high school setting. The exercise task used for heat-tolerance testing often consists of walking on a treadmill at 5 km/h on a 2% grade for 120 minutes at 40°C (104°F) and 40% relative humidity in an environmental chamber.[9,10] This task does not reflect the metabolic demands of most sports, such as football, cross-country, and soccer.

With improvements in the on-field care of EHS, athletic trainers (ATs) and other health care professionals need more specific guidelines to follow for a safe, progressive return to sport participation once an athlete has been cleared. Athletic trainers in the high school setting should have practical tools (ie, heart-rate [HR] and temperature monitors) and guidelines to adequately prepare patients with EHS for a progressive return to their sports. Current guidelines from the National Athletic Trainers' Association[4] and American College of Sports Medicine[7] provided generalized examples of exercise progression after EHS. However, sport-specific recommendations are lacking. Furthermore, ATs in a high school or youth sport setting need sport-specific RTP guidelines that are reproducible and practical in their settings.

Recently, several case reports and guidelines for RTP after EHS in the athletic setting have emerged.[11–13] For a triathlete returning to activity after EHS, Johnson et al[12] used a 15-day exercise and heat-exposure protocol to determine whether the athlete was able to adapt to exercise in the heat and to assess his physiologic responses to the exercise tasks. The RTP protocol initially consisted of cycling in a controlled environmental chamber and then progressed to triathlete training outdoors to ensure he was maintaining his cardiovascular fitness. Exercise heat-stress tests were administered on days 4 and 15 to measure the athlete's heat tolerance and the changes that occurred due to the exercise progression.

Another case[11] of RTP after EHS in a runner highlighted the importance of identifying the predisposing factors that led to the EHS when establishing the appropriate return to activity. Despite the lack of specific guidelines available for RTP after EHS, clinicians should examine the events that led to the EHS and use this information to prevent future occurrences. For example, lack of heat acclimatization, improper fitness status, and sleep deprivation are factors that can easily be addressed during the return-to-activity progression. When measuring signs of heat tolerance, ATs can monitor physiologic responses to exercise (ie, body temperature, HR) and the signs and symptoms of heat stress (ie, nausea, headache, fatigue).[13] A graded exercise progression can be adapted to the particular sport, and the patient can be monitored throughout the process.

Researchers[1,2,14–16] have shown a higher incidence of EHI during football activities and strength and conditioning sessions than during other sports. Therefore, RTP guidelines for ATs, physicians, and other health care providers to follow need to be established to ensure a safe return to football activities. The progressive return to football should include monitoring the patient during these activities and gradually increasing the exercise duration, intensity, and equipment worn. To our knowledge, no published data exist on RTP after EHS in a high school football player. Therefore, the purpose of our case study was to present a functional RTP progression after an EHS in a 17-year-old high school football player.

CASE PRESENTATION

Background

A 17-year-old male high school defensive tackle (height = 185 cm, mass = 145.5 kg) with no pertinent medical history incurred an EHS during the off-season. The patient was participating in an off-season conditioning test on a warm afternoon (temperature = approximately 34°C [93°F], relative humidity = 53%). This test took place 1 day before the official season was set to start, and no AT or other medical personnel was on the field at the time of the incident. After completing the conditioning test (14- × 110-yd [12.6- × 99.0-m] sprints), the patient fell to the ground and reported difficulty breathing. He was conscious but very anxious, and he exhibited central nervous system dysfunction (ie, acting "out of sorts").

The strength and conditioning coach notified an AT who was at the school but not on the field at the time and then called emergency medical services. The AT evaluated the patient on the field and noted tachypnea, an elevated pulse, and central nervous system dysfunction. This patient was normally very quiet and reserved. However, when the AT arrived, he was panicking, saying that he was dying and was very scared. He was very agitated, restless, and inconsolable. He also became combative, yelled at coaches, and began throwing water bottles. Emergency medical services arrived shortly after the AT arrived on the field, and the patient was immediately transported to a local hospital. On-field differential diagnoses included EHS, heat exhaustion, sickle cell-associated collapse (exertional sickling), rhabdomyolysis, and cardiac arrhythmia.

Hospital Care

During transport to the hospital via emergency medical services, the patient became extremely combative and removed his intravenous catheter. After arriving at the local emergency center, his initial vital signs included an HR of 178 beats/min, blood pressure of 120/44 mm Hg, and oral temperature of 39.6°C (103.3°F). Initial hospital care included 4 L of intravenous normal saline and 2 mg of both lorazepam and hydromorphone, as the patient reported severe pain secondary to muscle spasms in his back and lower extremities. The patient was then transferred to a pediatric tertiary hospital because he was 17 years of age and the initial hospital did not admit patients under 18 years of age. After transfer (approximately 2 hours after the on-field event), vital signs included an HR of 155 beats/min, blood pressure of 114/50 mm Hg, and oral temperature of 39.3°C (102.7°F). The athlete was admitted to the children's hospital, where he remained for 11 days.

After admission, the patient had an elevated creatine phosphokinase level of 857 U/L (normal range = 45–260 U/L),[17] indicative of early muscle breakdown. Despite aggressive hydration with 4 L of intravenous fluids, the patient also had an elevated creatinine level of 2.6 mg/dL (normal range = 0.6–1.2 mg/dL)[17] and abnormal liver enzyme levels. Approximately 4 hours after collapse, the patient's oral temperature was 38.1°C (100.6° F). His vital signs normalized over approximately 12 hours, and he remained hyperthermic for 5 hours. During the 11-day hospitalization, the patient was treated for elevated creatine phosphokinase, alanine aminotransferase, and aspartate aminotransferase levels that peaked at greater than 48 000 (upper limit of the analyzer), 4839, and 12 231 U/L, respectively. Normal levels for aspartate aminotransferase and alanine aminotransferase are less than 40 U/L and less than 66 U/L, respectively.[17] He experienced acute renal failure with an elevated creatinine level, which peaked at

Table 1. Laboratory Results After Exertional Heat Stroke: Days 1 Through 72

Value	Day 1	2	3	5	7	10[a]	37	53	72
Creatinine, mg/dL	2.60	2.58	2.68	2.72	2.14	1.79	1.05	1.17	1.08
Blood urea nitrogen, mg/dL	19	28	21	26	32	34	16	16	19
Aspartate aminotransferase, U/L	48	NA[b]	12 231	5360	3869	669	85	99	78
Alanine aminotransferase, U/L	44	NA[b]	4839	2559	1805	943	130	90	60
Creatine phosphokinase, U/L	857	>48 000	>48 000	>48 000	>48 000	8939	663	2209	709

Abbreviation: NA, not available.

[a] The patient was discharged from the hospital on day 11.

[b] Value was not checked on day 2.

2.72 mg/dL (Table 1). A hemoglobin electrophoresis indicated the athlete did not have sickle cell trait.

Eleven days after the on-field incident, the patient was discharged from the hospital, and his outpatient care was transferred to a primary care sports medicine physician. Weekly evaluations were conducted, and laboratory values were monitored (Table 1). Thirty-eight days after the initial event, the patient's laboratory tests and lack of symptoms led to clearance for initiating RTP. The patient was also followed through outpatient consultations with physicians specializing in gastroenterology and hepatology and cardiology. The physicians and athletic training staff worked closely to create an appropriate RTP protocol for football and outlined guidelines for safely administering it. The protocol was modified from a recently published protocol.[13]

Functional Progressive Return to Football

After the physician's clearance, the 14-day exercise protocol was followed over a 3-week period that started with light activity and progressed to moderate speed and agility exercise, to football drills, and finally to football practice (Table 2). The McDermott[13] protocol was designed as a functional progression for return to athletic activity after physician clearance and consists of a 14-day progression. The protocol recommends monitoring temperature and HR and progressing exercise via suggested HR-based intensity, exercise duration, and phasing in of equipment.[13]

During exercise, the patient's body temperature was monitored using ingestible thermistors (HQ Inc, Palmetto, FL). He ingested a thermistor approximately 5 to 6 hours before each exercise session, and gastrointestinal temperature (T_{GI}) was monitored regularly during the exercise sessions (Figures 1 and 2). On day 3, the patient's T_{GI} was not recorded, as the exercise session took place in the morning and he had passed the pill from the previous day. His HR was also monitored during each exercise session via a chest-strap HR monitor (Polar USA, Lake Success, NY). For each session, a designated target HR range was set as the minimum and maximum thresholds for exertion (Table 2).[13] In addition, the patient's rating of perceived exertion (RPE)[18] was monitored during exercise. His fluid consumption during each exercise was measured (Table 3), and his seminude body mass was measured and recorded before and after each exercise session to determine his percentage of body-mass loss ([pre-exercise body mass − postexercise body mass]/pre-exercise body mass) × 100 and sweat rate ([pre-exercise body mass − postexercise body mass] + fluid consumed − urine volume)/time.[19] Urine color was also recorded at the start of each exercise session to ensure euhydration. The criteria for stopping exercise consisted of a maximum T_{GI} of 39.5°C (103.1°F), HR greater than 90% of maximum, or symptoms of heat stress.[13]

The AT, strength and conditioning coach, and position coach worked together to develop an exercise program that was safe but also met the demands of football and the patient's position. Given that the athlete was a defensive end, the football coach and strength and conditioning coach were concerned about his strength losses and the amount of detraining he likely experienced during his time away from football and the weight room. A resistance-training program was implemented by the strength and conditioning coach during the second week of the RTP protocol.

The athlete progressed through the protocol without substantial adverse events; however, in the first week, he had a few episodes of nausea and vomiting during some of the exercise sessions. He was referred to a physician specializing in gastroenterology and hepatology, who attributed the vomiting and nausea to gastritis. The patient was treated with a proton pump inhibitor and H2 blocker, which resulted in prompt resolution of symptoms. He successfully completed the entire RTP exercise protocol on day 58 post-EHS. By the end of the protocol (day 14), the patient had completed a full football practice with the team. His mean temperature was 38.6°C (101.5°F) and mean HR was 139 beats per minute. He was also completely asymptomatic and had no indication of heat strain or heat intolerance. Per the cardiologist's recommendations, the patient underwent a cardiac stress test on day 59 that revealed normal function without residual damage from the EHS event. He was officially cleared for full football participation on day 60.

Uniqueness

Whereas EHS is rare in young athletes,[15,20] RTP after EHS in this population has not been documented in the literature. A paucity of research or information exists on RTP protocols for athletes, particularly those returning to American football in the high school setting. As stated, the existing return-to-activity guidelines come from military protocols[9,10] or consist of generalized recommendations for exercising individuals.[4,8] Authors[11,12] of recent case reports provided RTP guidelines for a particular sport or physical activity (ie, running or triathlon). To our knowledge, we are the first to document a step-by-step, individualized RTP protocol[13] to prepare a high school football player for a safe return to his sport and position. In addition, resistance training was incorporated into the RTP progression to ensure that he would be prepared for his sport.

Another unique aspect of this case was the interprofessional teamwork of several ATs, physicians, and coaches. The focus of our efforts was to ensure heat and fitness tolerance while providing a safe return to American football. The use of the latest guidelines[13] and the communication among the sports medicine team resulted in this athlete recovering with no lasting effects, successfully and safely completing the RTP protocol 58 days from his initial heat stroke, and fully returning to American football. This case also demonstrated the effectiveness of the graded return to sport for a high school football player; he competed in the final 5 games of the season and continued playing at the collegiate level.

DISCUSSION

The purpose of our paper was to report the case of a 17-year-old high school football player (defensive end) who sustained an EHS and successfully completed a functional return to football. Whereas the occurrence of the EHS during an off-season conditioning session should not be overlooked, this was an opportunity to focus on an evidence-based approach to safely return the patient to football. Despite the advances in education and research on preventing, recognizing, and managing EHS, appropriate and practical guidelines for RTP are scarce. In particular, many existing guidelines for RTP after EHS were designed for use in the military setting or for those with access to an environmental heat chamber.

When deciding whether an athlete can safely return to activity after EHS, clinicians should ask themselves a few questions to determine how they can prevent further occurrences, both for the individual athlete and potentially for others (Figure 3). Before beginning the RTP process, the sports medicine team must determine if the patient has recovered from the EHS and what provoked the event. Next, a needs analysis must be performed to determine the requirements of the sport to which the athlete is returning, as well as special considerations for his or her position in that sport. The RTP protocol must be individualized to the patient, suitable for a safe return to the particular sport and environment, and realistic for the setting and availability of equipment.

Recovery After EHS

Exertional heat stroke is the most severe EHI that occurs when metabolic heat production and the environment overwhelm the body's ability to thermoregulate.[4] It may result in a cascade of physiological responses as the body attempts to maintain thermal equilibrium during uncompensable heat stress.[21,22] Recovery after EHS depends on the amount of organ damage sustained during the event, as well as the athlete's ability to tolerate heat. One EHS event has the potential to impair all organs and body systems.[23] In some cases, a full recovery from EHS is not possible.[4,24]

The morbidity and mortality associated with EHS are directly related to the amount of time an individual's body temperature remains above a critical threshold. This depends specifically on the degree of hyperthermia present and how soon the athlete was cooled. Therefore, EHS often results in liver dysfunction and acute renal failure,[21] which may be reversible if the patient's body temperature does not remain dangerously elevated for an extended time.

In this case, the EHS occurred during an off-season conditioning session in the high school setting, where ATs are often not present. The AT was not on the field, and the athlete could not be cooled onsite before transport. Given the heat-acclimatization guidelines that are enforced during preseason practices, the incidence of EHS during the first few days of football practice has drastically decreased.[3,25] However, conditioning sessions occurring before the official start of the season do not have state-regulated guidelines for heat acclimatization, exercise progression, or medical coverage. Unfortunately, the emergency department did not use aggressive cooling to treat this patient. Aggressive cooling for EHS patients via cold-water immersion should be the standard of care in all settings, including emergency departments. The lack of rapid cooling likely explains why he experienced renal failure and transaminitis.

The most recent National Athletic Trainers' Association position statement[4] on EHIs recommends a 7- to 21-day rest period, normal laboratory results, and physician clearance before a return to activity. In this case, the patient was hospitalized for 11 days and experienced substantial sequelae due to the EHS. At that time, he was under the care of his primary physician with additional consultations from physicians with expertise in gastroenterology and hepatology and cardiology. Once the patient's laboratory results returned to normal 38 days after the EHS episode, a sports medicine team was assembled to ensure an individualized, safe return to sport. Even with the gradual, progressive return to activity, the patient initially experienced several signs and symptoms of heat intolerance, which led to a delay in the process and follow-up examinations with various physicians. Therefore, the recovery from EHS should be individualized and depend on the presence of any sequelae resulting from the event.

Determining the Cause Before RTP

Various factors can lead to an increase in heat storage along with an inability to adequately dissipate heat in individuals who experience EHS. Exertional heat stroke occurs due to a combination of these intrinsic and extrinsic factors.[4,26] Intrinsic factors may include the level of heat acclimatization, physical fitness, illness, or sleep deprivation, whereas extrinsic factors may include improper work-to-rest ratios, physical demands unmatched to physical fitness, or dangerous environmental conditions.[4,26] Until these predisposing factors are identified and addressed, the patient recovering from EHS should not begin exercising, especially in a hot environment. In our patient, several factors were involved. Most notably, the athlete had only been living in a hot, humid environment for a few days before he participated in a strength and conditioning test. Unfortunately, no mandates currently exist on the proper progression or heat acclimatization during strength and conditioning activities before the official preseason begins. Recent consensus statements[1,3] have brought this to light, and the Korey Stringer Institute[27] has worked extensively to help state high school associations establish more sound heat

Table 2. **Progressive Football-Specific Return-to-Play Exercise Program After Exertional Heat Stroke** Extended on Next Page

Session	Day	Activity (% Heart-Rate Maximum)	Duration	Type of Exercise
1	1	Light activity (50%–60%)	30 min	Stationary bicycle or jogging on a treadmill
2	2	Moderate activity (50%–65%)	60 min	Core activation, open and closed chain muscle activation, specific strength, and dynamic mobility and activation
3	3	Moderate activity (50%–65%)	60 min	Same as day 2
4	4	Moderate activity (50%–65%)	60 min	Same as day 2
5	5	Moderate activity (50%–75%)	90 min	Same as day 2
6	6	Moderate activity (50%–75%)	90 min	Same as day 2
7	12	Moderate activity (50%–75%)	90 min	Same as day 2
8	13	Light to moderate activity (40%–65%)	90 min	Same as day 2
9	14	Light to moderate activity (40%–65%)	90 min	Movement, open and closed chain muscle activation, dynamic mobility, speed drills, and football-specific drills with coach
10	15	Light to moderate activity (40%–65%)	90 min	Same as day 9
11	17	Moderate to intense activity (70%–90%)	90 min	Warm-up and cool down with the strength and conditioning work but all work was done with the position coach
12	18	Moderate activity (50%–65%)	60 min	Same as day 2
13	19	Moderate activity (60%–80%)	2 h	Warm-up and cool down with the strength and conditioning work but all work was done with the position coach
14	21	Intense activity (80%–100%)	3 h	Full midweek practice with the team, warm-up, special teams, individual drills, and team drills

policies for preseason practices in August. However, until the official first day of football, no current policies enforce off-season activities. This combination of a warm environment, a lack of heat acclimatization, physical fitness unmatched to exercise demands, and the metabolic heat production generated by the intensity of the fitness test likely contributed to this patient's EHS. According to his admissions paperwork at the hospital, the patient reported that he had not had much to eat and had very little water to drink that day as well.

After these possible causes of EHS have been determined, clinicians can decide how to correct or limit the risk factors and determine the best plan of action for returning the athlete to sport. Organizational factors that led to an EHS should be addressed with all involved. In this case, these organizational factors were addressed by the administration, in conjunction with the medical staff, to prevent future incidents. The education of coaches about EHS and preventing heat injury should include information about acclimatizing to the heat, introducing new conditioning activities gradually, and having adequate medical coverage at all exercise sessions.[2]

Intrinsic risk factors for EHS should be addressed individually with the athlete. An individualized exercise program to ensure physical fitness along with a gradual exposure to a hot, humid environment are necessary before a full return to sport. The patient's medical history and sleep, hydration, and nutritional practices should also be discussed.

Table 2. Extended From Previous Page

Specific Exercises	Notes
Stationary bicycle	• Very easy for the athlete
3-Way plank series, gluteal bridge holds, walking cradle, skipping cradle transverse squats, 4-way leg raise, fire hydrant series, Russian hamstrings, inverted toe touch, prone scorpion, and ladder drills	• Experienced elevated heart rate • Needed several breaks to decrease heart rate before next set of exercises
Neck rotations, arm circles, chain breakers, soldier walk, skipping soldiers, front balance, wide outs, transverse squats, 2-way leg swings, prisoner squats, prone scorpion, and ladder drills	• Heart rate was better on this day • Stayed at high range of heart-rate limit
Chain breakers and trunk twist, half-shin pull up and out, quadriceps pull stretch, skipping cradle, skipping soldiers, sumo squats, back lunge balance, leg swings, prone opposites, Russian hamstrings, and walking inverted toe touch	• Tolerated this day very well; slight increase in intensity compared with previous 2 d
Neck rotations, arm circles, dead bugs, cat and camel, half-shin pull up and out, half-walking cradle, sumo squats, back lunge balance, leg swings, prone opposites, walking inverted toe touch (forward and backward), prone scorpion, elbow to instep, skipping arm circles, and skipping arm grabs	• Increased total time by 30 min and moved outside to a covered turf area • Completed similar exercises to the previous days, adding repetitions and longer breaks
Chain breakers, trunk twist, dead bugs, cat and camel, quadriceps pull stretch, skipping cradle, soldier walk, body-weight squats, transverse lunge, leg swings, scorpion, prone opposites, skipping cradle, skipping arm circles, lateral walking with band, step with lunge, and ladder drills	• Had some muscle soreness over past few days • Used recovery methods, such as ice baths, foam rolling, vibration platforms, and intermittent compression boots
Neck rotations, arm circles, dead bugs, cat and camel, half-shin pull up and out, half-walking cradle, sumo squats, back lunge balance, leg swings, prone opposites, elbow to instep, skipping arm circles, skipping arm grabs, crow hops, side slides, ladder drills, and hurdle step series	• Had to repeat session 7 because he vomited during the session and reported nausea and vomiting over the past week • Cleared by physician to resume activity 5 d later
Chain breakers, trunk twist, dead bugs, cat and camel, quadriceps pull stretch, skipping cradle, soldier walk, body-weight squats, transverse lunge, leg swings, scorpion, prone opposites, skipping cradle, skipping arm circles, lateral walking with band, step with lunge, and ladder drills	• Wore a helmet for all exercises • Decreased exercise intensity to build up his tolerance
Neck rotations, arm circles, chain breakers, quadriceps pull stretch, skipping cradle, soldier walk, body-weight squats, transverse squats, leg swings, Russian hamstrings, prone opposites, butt-kicks in place fast leg, and build ups Position work: step over bags, stance and get off (on air and on sled), key reads with hand shield, and push/pull technique	• Completed 60 min of movement and speed followed by 30 min of on-field drills with a position coach
Similar to day 9	• Wore helmet and shoulder pads • Completed all activity on the football field • Completed 45 min of movement and speed and 45 min with position coach
Step over bags with change of direction, cone change-of-direction drills, stance get off (on air and sled), key reads with hand shield, walk/jog/run drill, and hoop drills	• Tolerated exercise well • Break in the second half of the session to allow heart rate to stay within target range
Same as day 2	• Repeat of day 2 inside the gymnasium with no equipment for sweat-rate calculation • Tolerated session very well
Step over bags with change of direction, cone change-of-direction drills, stance get off (on air and on sled), key reads with hand shield, walk/jog/run drill, hoop drills, wake-up drill, blitz read, and Indy pass-rush drills	• Completed longest session on the hottest day of the entire progression • Tolerated the session very well
Team warm-up, special teams, individual defensive-line drills, team defense drills, and cool down	• Fully participated with the team • Performed same number of repetitions as other defensive linemen

Individualizing an EHS RTP Protocol in the High School Setting

As with many other RTP protocols, individualization is extremely important when working with a patient who has had an EHS. A needs analysis of the particular sport and position is necessary for determining how the exercise prescription (exercise type, intensity, and duration) will meet the metabolic demands of the individual athlete. In the high school setting, it was very helpful to incorporate the knowledge of both the strength and conditioning coach and the sport/position coach. We used a sample RTP protocol[13] and adjusted the variables to meet the needs of our athlete.

To determine whether an athlete is heat tolerant after EHS, the AT must be able to monitor physiological measures, such as body temperature and HR. In addition, the sports medicine team must identify signs and symptoms of heat intolerance early in the RTP process to prevent another episode of EHS. Examples of heat strain may include lightheadedness, fatigue, nausea, or headache. Recognition of unique symptoms, which may present differently in each athlete, should be considered when examining the athlete's reaction to exercise. The AT and the sports medicine team in this case decided that ingestible thermistors were the most practical way to accurately monitor the athlete's body temperature while still allowing him to participate in various football-related activities. Whereas a cost was associated with this technique, the AT borrowed a measuring device for the RTP process. Other equipment (Table 4) needed to monitor the athlete before,

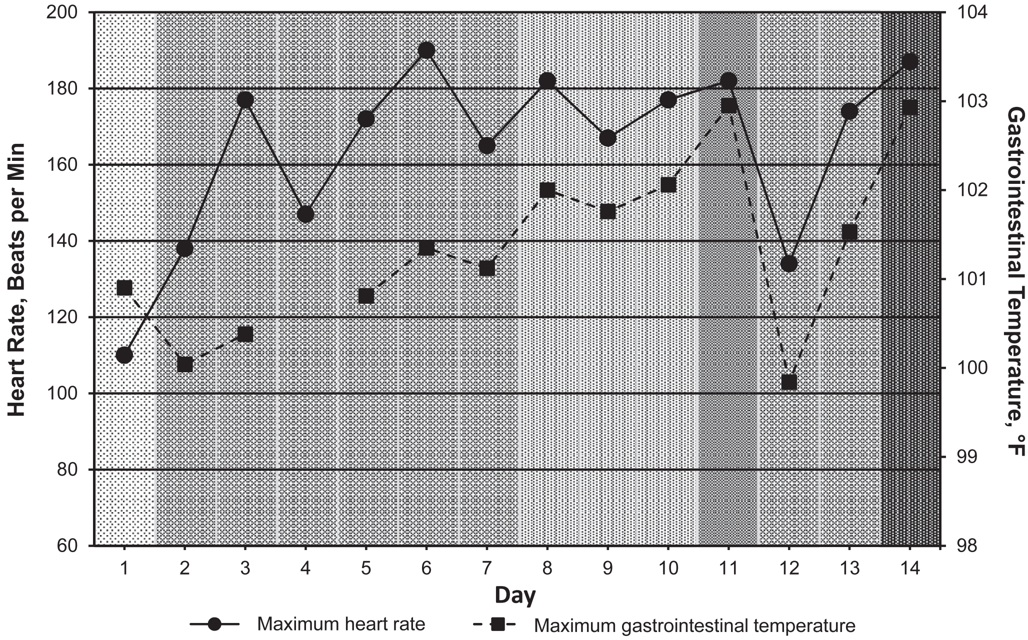

Figure 1. Maximum heart-rate and gastrointestinal-temperature responses during the 14-day return-to-play progression after exertional heat stroke. Shading represents exercise intensity for each day in correspondence with the exercise program in Table 2. Darker shading indicates a higher heart-rate range for that day.

during, and after exercise consisted of a standard HR monitor with chest strap, a body-mass scale, an RPE scale,[18] a small kitchen scale, and a urine color chart.[28] The kitchen scale was used to measure the fluid consumed during exercise.

All measurements were simple to take and easy to record. The AT weighed the athlete before and after each exercise session to determine his fluid losses and calculate his individualized sweat rate. The AT also measured the amount of fluid the athlete was given during each session and recorded his total fluid consumed. Whereas limiting the percentage of fluid loss during exercise to no more than 2% was important,[4,8] preventing hyperhydration was also important. As noted in Table 3, the athlete had substantial weight gain, which was due to excess fluid consumption, during the first few days of the protocol. When asked about this, the athlete believed his insufficient water intake on the day of his EHS led to the episode. The ability to measure

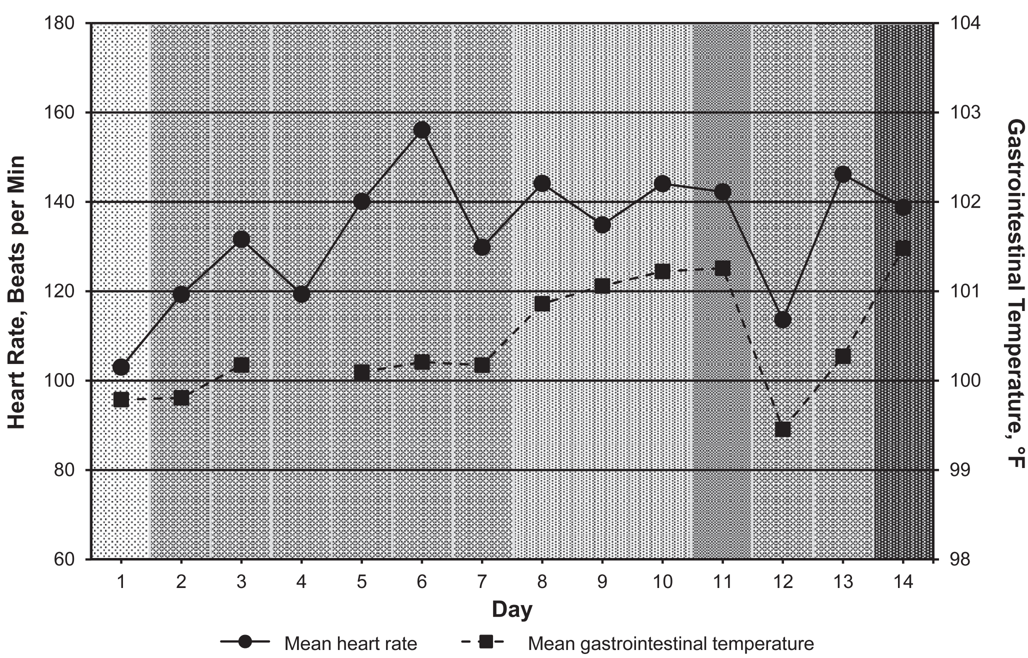

Figure 2. Mean heart-rate and gastrointestinal-temperature responses during the 14-day return-to-play progression after exertional heat stroke. Shading represents exercise intensity for each day in correspondence with the exercise program in Table 2. Darker shading indicates a higher heart-rate range for that day.

Table 3. Hydration Measures During 14-Day Return-to-Play Progression to Football After Exertional Heat Stroke

	Day													
Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Prepractice body weight, kg	136.6	136.4	136.5	137.6	138.8	138.4	137.4	138.7	139.5	139.0	138.0	139.4	137.0	139.5
Postpractice body weight, kg	139.2	136.9	137.0	138.0	139.6	138.5	137.5	139.2	139.0	137.5	137.0	139.3	137.0	139.5
Prepractice to postpractice difference in body weight, kg[a]	2.6	0.5	0.5	0.4	0.8	0.1	0.1	0.5	−0.5	−1.5	−1.0	−0.1	0.0	0.0
Fluid consumed, L	2.8	1.1	1.2	1.1	1.9	2.5	1.3	1.6	1.6	2.8	2.2	0.3	2.1	2.4
Exercise time, h	0.50	0.75	1.00	1.00	1.00	1.25	1.50	1.00	1.50	1.50	1.00	0.50	1.50	2.75
Sweat rate, L/h	0.4	0.8	0.7	0.7	1.1	1.9	0.8	1.1	1.4	2.9	3.2	0.9	1.4	0.9

[a] A positive value indicates weight gain, and a negative value indicates weight loss during exercise.

his fluid consumption and fluid loss during the RTP protocol resulted in an opportunity to educate the athlete about the events that led to his EHS and provided a means of prevention for the future. The urine color chart was also an easy method of educating the athlete about what his urine should look like (pale yellow) before exercising. The RPE scale was a perceptual measure of how hard the athlete believed he was working during the various football-related activities.

Monitoring the RTP process for the sport setting varies from that in the military setting because heat-tolerance testing often uses more conservative stopping criteria (body temperature > 38.5°C [101.3°F][3,25] or HR > 150 beats/min). Despite increased use of heat-tolerance testing in the athletic population, it is still not sufficient on its own to indicate whether an athlete can be cleared to return to sport in the competitive setting with higher exercise intensities and protective equipment.[9,12] Another interesting aspect not addressed in the literature is implementing or reintroducing a strength-training program appropriate for tackle football players. The graded, functional RTP protocol for football activities helped our patient with his progression; however, the strength and sport coaches were concerned about the detraining and decrements in muscular strength he likely experienced due to his EHS and inability to exercise for more than a month. The success of this case can be

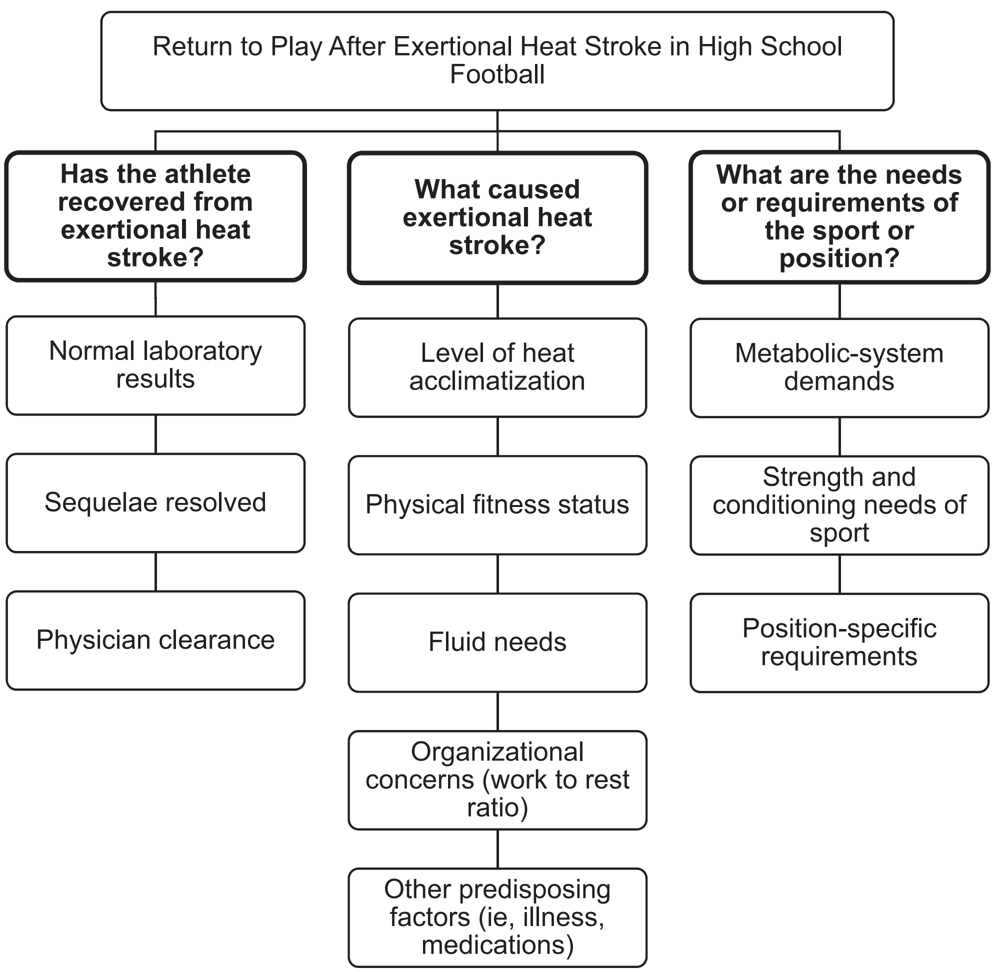

Figure 3. Questions a clinician should ask when returning an athlete to football after exertional heat stroke.

Table 4. Necessities for Implementing a Return-to-Play Protocol for an Athlete With Exertional Heat Stroke

- Heart-rate monitor
- Accurate body-temperature monitoring
  - Rectal thermistor or ingestible thermistor (pill)
- Monitor signs and symptoms of heat stress
- Hydration status
  - Body-weight changes, fluid consumed, sweat rate, and urine color or specific gravity
- Exercise protocol
  - Work with position and strength coaches
  - Exercise should match the athlete's sport, position, intensity, etc

attributed to the communication and teamwork among the ATs, physicians, coaches, and athlete that ensured all elements were addressed for a safe return to football participation.

Patient Education

Throughout the process of returning this athlete to football participation, it became apparent from daily interactions with him and tracking his hydration measures (Table 3) that patient education was necessary in the areas of hydration, nutrition, and EHIs. The athlete did not have a good understanding of EHS, why it happened to him, and what he needed to do to prevent future episodes. A thorough history regarding the day of the incident and the days leading to the EHS revealed that he was misinformed about heat illness and hydration. In addition, the hospital notes stated he had not eaten sufficiently on the day of his EHS.

When beginning the RTP protocol, the athlete overcompensated by hyperhydrating during initial exercise sessions (Table 3). For instance, he drank nearly 3 L of water on day 1 while riding a stationary cycle indoors for 30 minutes. The athlete believed that his lack of proper hydration the day of his EHS led to his collapse. Measuring pre-exercise and postexercise body weights and his fluid consumption during the RTP process enabled us to educate him on the importance of tracking hydration and ensured that he was aware of his individual fluid needs. We used his prepractice and postpractice body weights, fluid consumption, and urine color to demonstrate the importance of these measures. We also explained the dangers of overhydration and the importance of heat acclimatization, proper fitness, and factors that could lead to EHS.

CONCLUSIONS

Despite what is known about preventing, recognizing, and treating EHS, little is known about the functional progression and RTP of an athlete after EHS. The purpose of our report was to present the case of a 17-year-old football defensive end who sustained EHS during a conditioning session and made a full RTP after a functional progression to full tackle football. The RTP protocol consisted of monitoring the patient throughout various progressions on and off the field. Measures included body temperature, HR, pre-exercise and postexercise body weights, fluid consumption and sweat rate, and sport-specific performance measures and progress in the weight room (Table 4). This case demonstrated that an AT in the high school setting safely returned an athlete to participation by using a gradual RTP progression after obtaining physician clearance. This case also highlights the importance of communication and teamwork among the AT and other medical and fitness professionals for a safe return to sport participation. The RTP in this patient was successful because of a team effort, which included ATs, sports medicine physicians, the strength and conditioning coach, and the player's position coach. The patient made a full return to football 60 days after the incident and continued to play football at the collegiate level.

ACKNOWLEDGMENTS

We thank Brendon P. McDermott, PhD, ATC, for his consultation during this case. We also thank the athlete for allowing us to document his case.

REFERENCES

1. Casa DJ, Almquist J, Anderson SA, et al. The Inter-Association Task Force for Preventing Sudden Death in Secondary School Athletics Programs: best-practices recommendations. *J Athl Train*. 2013;48(4): 546–553.
2. Casa DJ, Anderson SA, Baker L, et al. The Inter-Association Task Force for Preventing Sudden Death in Collegiate Conditioning Sessions: best-practices recommendations. *J Athl Train*. 2012;47(4): 477–480.
3. Casa DJ, Csillan D, Armstrong LE, et al. Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*. 2009;44(3):332–333.
4. Casa DJ, DeMartini JK, Bergeron MF, et al. National Athletic Trainers' Association position statement: exertional heat illnesses. *J Athl Train*. 2015;50(9):986–1000.
5. Casa DJ, Guskiewicz KM, Anderson SA, et al. National Athletic Trainers' Association position statement: preventing sudden death in sports. *J Athl Train*. 2012;47(1):96–118.
6. Lopez RM, Casa DJ, McDermott B, Stearns RL, Armstrong LE, Maresh CM. Exertional heat stroke in the athletic setting: a review of the literature. *Athl Train Sports Health Care*. 2011;3(4):189–200.
7. O'Connor FG, Casa DJ, Bergeron MF, et al. American College of Sports Medicine roundtable on exertional heat stroke–return to duty/return to play: conference proceedings. *Curr Sports Med Rep*. 2010; 9(5):314–321.
8. Armstrong LE, Casa DJ, Millard-Stafford M, Moran DS, Pyne SW, Roberts WO. American College of Sports Medicine position stand: exertional heat illness during training and competition. *Med Sci Sports Exerc*. 2007;39(3):556–572.
9. Kazman JB, Heled Y, Lisman PJ, Druyan A, Deuster PA, O'Connor FG. Exertional heat illness: the role of heat tolerance testing. *Curr Sports Med Rep*. 2013;12(2):101–105.
10. Lisman P, Kazman JB, O'Connor FG, Heled Y, Deuster PA. Heat tolerance testing: association between heat intolerance and anthropometric and fitness measurements. *Mil Med*. 2014;179(11):1339–1346.
11. Adams WM, Hosokawa Y, Huggins RA, Mazerolle SM, Casa DJ. An exertional heat stroke survivor's return to running: an integrated approach on the treatment, recovery, and return to activity. *J Sport Rehabil*. 2016;25(3):280–287.
12. Johnson EC, Kolkhorst FW, Richburg A, Schmitz A, Martinez J, Armstrong LE. Specific exercise heat stress protocol for a triathlete's return from exertional heat stroke. *Curr Sports Med Rep*. 2013;12(2): 106–109.
13. McDermott BP. What is the proper functional progression for an athlete returning to play following exertional heat stroke? In: Lopez RM, ed. *Quick Questions in Heat-Related Illness and Hydration:*

Expert Advice in Sports Medicine. Thorofare, NJ: SLACK Inc; 2015: 143–147.
14. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med*. 2013;44(1):8–14.
15. Tripp BL, Eberman LE, Smith MS. Exertional heat illnesses and environmental conditions during high school football practices. *Am J Sports Med*. 2015;43(10):2490–2495.
16. Yeargin SW, Parsons JT, Dompier TP, Casa DJ, Kerr ZY. Epidemiology of exertional heat illnesses in NCAA athletes, 2009/10–2014/15 [abstract]. *Med Sci Sports Exerc*. 2016;48(suppl 1 5S): 879.
17. Huggins RA, O'Connor FG. When can an athlete return to play following an exertional heat illness? In: Lopez RM, ed. *Quick Questions in Heat-Related Illness and Hydration: Expert Advice in Sports Medicine*. Thorofare, NJ: SLACK Inc; 2015:137–142.
18. Borg G. Physical training: 3. Perceived exertion in physical work [in Swedish]. *Lakartidningen*. 1970;67(40):4548–4557.
19. Casa DJ, Armstrong LE, Hillman SK, et al. National Athletic Trainers' Association position statement: fluid replacement for athletes. *J Athl Train*. 2000;35(2):212–224.
20. Yeargin SW, Kerr ZY, Casa DJ, et al. Epidemiology of exertional heat illnesses in youth, high school, and college football. *Med Sci Sports Exerc*. 2016;48(8):1523–1529.
21. Epstein Y, Roberts WO. The pathophysiology of heat stroke: an integrative view of the final common pathway. *Scand J Med Sci Sports*. 2011;21(6):742–748.
22. Epstein Y, Roberts WO, Golan R, Heled Y, Sorkine P, Halpern P. Sepsis, septic shock, and fatal exertional heat stroke. *Curr Sports Med Rep*. 2015;14(1):64–69.
23. McDermott BP, Casa DJ, Yeargin SW, Ganio MS, Armstrong LE, Maresh CM. Recovery and return to activity following exertional heat stroke: considerations for the sports medicine staff. *J Sport Rehabil*. 2007;16(3):163–181.
24. Stearns RL, Casa DJ, O'Connor FG, Lopez RM. A tale of two heat strokes: a comparative case study. *Curr Sports Med Rep*. 2016;15(2): 94–97.
25. Yeargin SW, Casa DJ, Armstrong LE, et al. Heat acclimatization and hydration status of American football players during initial summer workouts. *J Strength Cond Res*. 2006;20(3):463–470.
26. Rav-Acha M, Hadad E, Epstein Y, Heled Y, Moran DS. Fatal exertional heat stroke: a case series. *Am J Med Sci*. 2004;328(2):84–87.
27. Adams WM, Scarneo SE, Casa DJ. State-level implementation of health and safety policies to prevent sudden death and catastrophic injuries within secondary school athletics. *Orthop J Sports Med*. 2017;5(9):2325967117727262.
28. Armstrong LE, Maresh CM, Castellani JW, et al. Urinary indices of hydration status. *Int J Sport Nutr*. 1994;4(3):265–279.

Address correspondence to Rebecca M. Lopez, PhD, ATC, CSCS, Department of Orthopaedics and Sports Medicine, University of South Florida, 13220 USF Laurel Drive, MDF 5115, Mail Code: MDC 106, Tampa, FL 33612. Address e-mail to rlopez@health.usf.edu.