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HEAT STROKE IN SPORTS: CAUSES, PREVENTION, AND TREATMENT

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KEY POINTS

- Heat stroke is always a risk in summer sports, especially football and running.
- Heat stroke is typically caused by a combination of hot environment, strenuous exercise, clothing that limits evaporation of sweat, inadequate adaptation to the heat, too much body fat, and/or lack of fitness.
- Early recognition and fast treatment of evolving heat stroke can save lives.
- Preventing heat stroke hinges on acclimation, hydration, pacing, cooling, and vigilance.
- Heat stroke is a medical emergency. The life-saving adage is: cool first and transport second.

INTRODUCTION

Summer football brings grueling workouts in brutal heat. For football players in the dog days, mild heat illness is common and grave heat stroke always a threat (Knochel, 1975). Since 1995, on average three players a year have died of heat stroke. Heat stroke also threatens runners and other athletes; in the 2001 Chicago Marathon, a young man in his first marathon collapsed of heat stroke at 26 miles and died soon after.

Heat illness can advance quickly in football players and runners, and early warning signs of heat stroke can be subtle. Yet early diagnosis and proper therapy can save lives; exertional heat stroke should be preventable. This article covers causes of heat stroke in sports and presents tips to recognition, prevention, and treatment.

RESEARCH REVIEW

Causes of Heat Stroke

Overmotivation.

Overmotivated athletes can overheat by doing too much too fast or trying to endure too long. An Australian runner, out of shape, sped to the front of a hot race and kept going hard until he dropped from heat stroke at 4.5 miles (Lee et al., 1990). The same happened to a novice runner who, on a mild day, sped up at the end of a six-mile race (Hanson et al., 1979). Both runners were lucky to live; speed and metabolic rate influence rectal temperature in distance racing (Noakes et al., 1991).

Agonizing tableaus of endurance were seen at the 1984 Los Angeles Olympic Games and the 1995 Hawaii Ironman Triathlon. In Los Angeles, marathoner Gabriela Andersen-Scheiss, not trained for heat, entered the stadium dazed and wobbling. In a final lap that seemed to last forever, she waved off help and collapsed at the finish. In Hawaii, seven-time winner Paula Newby-Fraser, losing her lead, skipped aid stations late in the run and collapsed near the end. After rest, cooling, and hydration, she was able to walk to the finish (Eichner, 1998).

Similar lessons come from the military. A soldier died of heat stroke marching at night, carrying extra weight. He completed just 2.5 miles (Assia et al., 1985). Running generates about twice the heat of marching. Of 82 heat-stroke cases in Israeli soldiers, 40% were from brief exercise, as in the first three miles of a run. Overmotivation was a risk factor (Epstein et al., 1999).

Football breeds a warrior mentality. Victims of heat stroke are described as "the hardest worker" or "determined to prove himself." During a hard practice on a hot day, the never-quit mentality can work against a player.

The 1-2 Punch.

Most heat-stroke deaths in football occur on Day 1 or 2 of two-a-days. A similar 1-2 punch applies in the military. In studying 1,454 cases of heat illness in Marine-recruit training, researchers implicated heat stress on the prior day as a factor (Kark et al., 1996). So a prime time for heat stroke is the day *after* an exhausting and dehydrating day in the heat.

Heat and Humidity.

In summer sports, it's not the heat, but the heat *and* humidity. In football, body temperature rises — in a sawtooth line — ever higher the longer practice goes on. So during a hard practice in full gear, heat stroke is possible at any combination of ambient temperature above 80 ˚F (26.7 ˚C) and relative humidity above 40% (Kulka & Kenney, 2002).

Unacclimated.

Getting heat-fit takes time. Lack of acclimation is a cardinal predictor of heat stroke in football. Triathletes unacclimated to the tropical heat of Hawaii also suffer. Acclimation, much of which occurs in a week or two, leads to better drinking and the body holds onto water and salt, increasing blood volume so the heart pumps more blood at a lower heart rate. Heat-fit athletes

also sweat sooner, in greater volume, and over a wider body area, so they stay cooler.

Dehydration.

Athletes in the heat can sweat 1-2 L an hour, and most athletes drink less than they sweat. The result is dehydration. Dehydrating only 2% body weight — just five pounds in a 250-pound linebacker — can impair physical performance (Walsh et al., 1994). Dehydration increases heart rate and decreases cardiac output. Perceived exertion of the work increases as dehydration drains mental sharpness and willpower along with muscle power and endurance. Dehydrated players also heat up faster (Latzka & Montain, 1999).

Uniform Penalty.

The football uniform insulates players. As more gear is added — from shorts and shirt to pads and helmet to full uniform — players heat up faster, get hotter, and cool slower (Kulka & Kenney, 2002). Runners too should avoid vapor-impermeable clothing that limits sweat evaporation. In 1999, actor Martin Lawrence jogged in heavy clothes and a wool hat in 100 ˚F (37.8 ˚C) to lose weight. He collapsed with a temperature of 107 ˚F (41.7 ˚C) and spent three days in a coma.

Heat Stroke and Body Mass.

Fat athletes are prone to heat stroke. Extra fat is an extra load, increasing exertional heat production. The NFL has nearly 300 players who weigh 300 pounds or more, six times as many as a decade ago. Nor is extra fat the only bulk problem. When a 270-pound player adds 30 pounds of muscle, he can generate more heat, but he does not add enough extra surface area to shed that extra heat. So huge lineman can be heat bombs.

Fitness Protects.

Physical fitness, especially aerobic fitness, confers some of the same physiologic benefits as heat acclimation (Latzka & Montain, 1999). Fitness also makes workouts less taxing. So football players who come to camp fit are at lower risk of heat stroke.

In contrast, lack of fitness increases risk of heat illness. In a study of 391 cases of heat illness in Marine recruits, time to run 1.5 miles (and body mass index) predicted risk. A recruit unable to run 1.5 miles in 12 minutes (and with a body mass index over 22) had eight times the risk of heat illness in basic training as did one with a lower body mass and faster run time (Gardner et al., 1996).

Supplements.

Stimulants speed heat buildup, so products that speed players up heat them up. Amphetamine and cocaine are the most dangerous, but ephedra is the most prevalent. Many dietary supplements tout ephedra for weight loss or quick energy. But ephedra poses many health risks, including heat stroke. Heat-stroke risk is compounded by drugs that impair sweating, like some antihistamines, antispasmodics, and medications for depression.

Recognizing Heat Stroke

Beyond Fluids.

Heat stroke in football sometimes seems to hit with surprising speed. When this happens, a common theme of bewildered staff is, “But he got lots of fluids.” The misconception is that hydration prevents heat stroke. The truth is that hydrating is critical but not sufficient to prevent heat stroke. Stress fluids but think “beyond fluids.” All the factors described above can work together to cause heat stroke.

Compared to the other common causes of collapse in football — trauma, heart disease, asthma, sudden blood clots tied to sickle cell trait (sickling crisis) — heat stroke is often slow to evolve, and the vigilant observer can detect early warning signs and avoid the worst outcome. Heat stroke is always a threat during hard drills on hot days, especially in hefty players in full gear.

Early Warning.

Early warning signs of impending heat stroke may include irritability, confusion, apathy, belligerence, emotional instability, or irrational behavior. The coach may be the first to note that a player, heating up, can no longer think clearly. Giddiness, undue fatigue, and vomiting can also be early signs. Paradoxical chills and goose bumps signal shutdown of skin circulation, portending a faster rise in temperature. The player may hyperventilate — just as a dog pants — to shed heat; this can cause tingling fingers as a prelude to collapse. Incoordination and staggering — “running like a puppet on a string”— are late signs, followed by collapse with seizure and/or coma. Upon collapse, as in all three football players who died in 2001, core body temperature can be 108 ˚F (42.2 ˚C) or higher.

Preventing Heat Stroke

Cooler is Better.

The cooler athletes stay, the better they play. In team sports, take frequent cooling breaks. Provide shade, ice water, and misting fans for rest breaks. As the temperature rises, reduce practice pace and duration and increase rest breaks. Have players sit in cold tubs after practice. Hold practices earlier and later, with more time between — time for rest, recovery, and cooling.

In hot road races, tips include: stay hydrated; run comfortably, avoid long sprints; “read” your body; and seek help early for illness. Confusion can limit self-diagnosis, so race monitors can help. Runners in trouble can become belligerent, refusing to stop until they collapse. Naïve crowds may urge on suffering athletes, chanting, “Keep going, you can make it.” Monitors can recognize early warning: incoherence, irrational or bizarre behavior, or poor competitive posture (Eichner, 1998).

Drink Sensibly.

Hydration helps prevent heat stroke, but there is no advantage to consuming fluid in excess of sweat loss. Likewise it’s not necessary to overhydrate the night before or during the hours prior to a long run or practice. Teach athletes to drink for their needs. During training have them weigh in before and after a workout and learn to adjust fluid intake to minimize weight loss. If weight loss does occur, rehydration after activity is critical; drink 20-24 ounces of fluid for every pound of weight loss. Also, eat foods with a high water content (fruits & vegetables). A sports drink beats plain water because it has sugars to fuel muscles and brain, flavoring to encourage drinking, and sodium to hold fluid in the body and help replace sweat losses.

Be Prepared.
High heat can overwhelm even physically fit and hydrated players. A week or two of moderate physical activity in the heat, say jogging 30-45 minutes a day, can jump-start heat acclimation. Athletes should never go from a sedentary, air-conditioned life into a hard-charging summer athletic camp.

Bird-dog the Big Guys.
In football, focus on high-risk players. Spot subtle signs of physical or cognitive decline. Weight loss the first few days is fluid loss, not fat loss. Dizziness and drop in blood pressure on standing signal fluid and sodium depletion. Urine should resemble lemonade, not apple juice. Weigh before and after practice. Morning weight should be back up, near baseline, and body temperature should be normal before the player takes the field. When in doubt, hold them out.

Uniform Concerns.
In football, limit gear in the heat. Suit-up in stages in summer camp: shorts and T-shirt the first day or two; then add helmet; then shoulder pads and jersey; finally the full uniform. Remove helmet and pads for fitness runs. Boxers and wrestlers should not run in plastic suits to lose weight.

Counter the Culture.
Some football players are overmotivated by pride and driven by tough coaches. They believe no limits exist. They ignore warning signs. Never let the warrior call the shots. Some runners also have a never-say-die mentality. The man who died of heat stroke in the Chicago Marathon may have pushed the pace trying to keep up with his brother. Heat stroke is rare in female athletes. And in Marines, although attack rates are the same by gender, heat illness is milder in females (Kark et al., 1996). These gender trends raise questions of biology and behavior.

Train, Don't Strain.
Start slow. Athletes cannot safely start full tilt in stifling heat. Other than massive bleeding, exercising all-out in extreme heat is the greatest strain on the cardiovascular system. Pace and duration should "start low and build slow." Don't drive halfway to heaven on the first day.

Off-field Behavior.
Off-field behavior also counts. Athletes sleeping poorly or ill, especially with vomiting, diarrhea, or fever, are more prone to heat stroke. The same applies to taking diuretics or drinking alcohol. Monitor all medications.

Pre-cooling?
Linemen and other athletes at risk of heat stroke may benefit from pre-cooling before workouts. A half hour in a cold bath will reduce core temperature and increase the buffer against heat stroke. Pre-cooling mimics Mother Nature in that after a week of daily exercise in the heat, basal body temperature is reduced about 0.9 ˚F (0.5 ˚C) (Buono et al., 1998). Another benefit may be improved hot-weather running or cycling (Booth et al., 1997; Gonzalez-Alonzo et al., 1999). Using cold towels or splashing cold water on face, head, and neck provides a psychological boost but little physiological benefit.

Treating Heat Stroke

Medical Emergency.
In heat stroke, every minute counts. When core temperature is very high, body and brain cells begin to die, so fast cooling is vital. Early features are subtle central nervous system (CNS) changes — altered cognition or behavior — and core temperature over 104-105 ˚F (40.0-40.6 ˚C). When an athlete collapses, the best gauge of core temperature is rectal temperature; oral, axillary, or ear-canal temperature will not do. Advanced features are collapse with wet skin, core temperature over 106-107 ˚F (41.1-41.7 ˚C) and striking CNS changes — delirium, stupor, seizures, or coma (Roberts, 1998).

Cool First.
Field treatment is fast cooling. No faster way to cool exists than dumping the athlete into an ice-water tub. Submerge the trunk — shoulders to hip joints. Research suggests ice-water immersion cools runners twice as fast as air exposure while wrapped in wet towels (Armstrong et al., 1996). The Marines also use ice-water cooling (Kark et al., 1996). Recent field research with volunteer runners suggests cold water may cool as fast as ice water (Clements et al., 2002).

Monitor Closely.
Check the athlete every few minutes for rectal temperature, CNS status, and vital signs. Useful is an indwelling rectal probe with a thermometer. To prevent overcooling, remove the athlete from the tub when rectal temperature drops to 102 ˚F (38.9 ˚C). An athlete can be cooled from 108-110 ˚F (42.2-43.3 ˚C) to 102 ˚F (38.9 ˚C) in 15-30 minutes (Roberts, 1998).

Transport Second.
Cool first, transport second. Send the heat-stroke athlete to the hospital after cooling. With fast cooling, survival rate approaches 100% (Kark et al., 1996). In fact, fast cooling can allow athletes to walk away in good health. For example, yearly at the Falmouth Road Race, up to 10-15 runners collapse with temperatures from 106-110 ˚F (41.1-43.3 ˚C), but over a decade nearly all such runners, after ice-water immersion, walked away. After cooling, runners are observed for 20-60 minutes to ensure they are drinking fluids and have normal vital signs and good cognition (Roberts, 1998).

Recovery.
We need more data on recovery. Anecdotally, most runners cooled on-site return to racing in weeks. Some research suggests heat-stroke patients may have brief or lasting heat intolerance, but whether this is innate or a result of the heat stroke is unclear (Shapiro et al., 1979). Other research suggests 90% of heat-stroke patients have normal heat tolerance within two months (Armstrong et al., 1990). Long-term follow-up of 922 cases of heat illness in Marine recruits is encouraging — subsequent serious heat illness occurs in less than 1% of these Marines per year (Phinney et al., 2001). It seems likely that most athletes treated early for heat stroke and educated on preventing it can return safely to their sport within weeks.

SUMMARY

Many factors — environmental and personal — contribute to heat stroke. Early warning signs of impending heat stroke may include irritability, confusion, apathy, belligerence, emotional instability, irrational behavior, giddiness, undue fatigue, chills,

goose bumps, and vomiting. Practical tips for preventing and treating heat stroke in sports are outlined, with the vital adage being: Cool first; transport second. Research on recovery is sparse, but it seems likely that most athletes treated early for heat stroke can soon safely return to their sport.

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SUPPLEMENT VOLUME 15 (2002) ■ NUMBER 3

HEAT STROKE IN SPORTS: HOW TO PROTECT YOURSELF AND HELP YOUR TEAMMATES

Heat stroke is always a risk in any sport when it's warm, especially in football and in distance running such as the 10-k race. In football, the uniform insulates the player and increases the risk of heat stroke. Heat stroke is possible any time the air temperature is above 80 degrees F and the relative humidity is above 40%. Here are some tips that will help you protect yourself and help your teammates:

- Improving your physical fitness and adjusting your body to the heat over several days lower your risk of heat stroke. Don't jump from an easy, air-conditioned life into a summer athletic camp like football two-a-days.
- Get fit first, and adjust to the heat for a week or two before formal practices begin by jogging 30-45 minutes a day in the heat in shorts and T-shirt. Be prepared.
- The highest risk for heat stroke occurs in the first few days of training in hot weather. The largest and fattest athletes are the most heat-sensitive.
- On the field, read your body, don't defy Mother Nature, and never ignore early warning signs of illness. Train, don't strain. Don't drive yourself halfway to heaven to make the team.
- Take full advantage of every rest break. In football, seek shade, take your helmet off, and get in front of a misting fan. Sit in a cold tub right after practice. The cooler you stay, the better you play.
- Off the field, never skip meals, get plenty of fluids and salt, avoid alcohol, stay cool when you can, and get plenty of sleep.
- Heat stroke is a medical emergency. Early recognition and proper treatment can save lives.
- You may be the first to notice early signs of heat stroke in a teammate or running buddy. If so, pull him out, cool him down, and get help fast. When in doubt, cool first and transport to the hospital second.
- Other tips on what to do and what to watch for to avoid heat stroke in sports are listed in the tables.

TABLE S1. WHAT TO DO TO AVOID HEAT STROKE.

Come to the first practice physically fit and heat-fit
Report fever or illness to the athletic trainer
Show all your medicines to the trainer
Avoid stimulants like ephedra
Stay hydrated
Favor sports drinks over plain water
Watch urine: Should be plentiful and pale
Watch weight: Early weight loss is fluid loss
After a workout, drink 1½ pints of fluid for every pound of weight lost
Dizziness on standing up is caused by fluid and salt loss

(See additional chart on back)

TABLE S2.
WHAT TO WATCH FOR:
SIGNS OF HEAT STROKE

Fuzzy thinking

- Can't follow the plays
- Seems confused
- Suddenly forgetful
- Runs the wrong way

Bizarre behavior

- Talks nonsense
- Blank stare
- Laughs or cries at wrong time
- Yells in rage at coach or peers
- Wants to fight for no good reason

Physical decline

- Begins to lose coordination
- Sudden or unusual fatigue
- Nausea and vomiting
- Chills and goose bumps
- Overbreathing, tingly fingers
- Wobbles or staggers, collapses
- Seizure or coma