The Science of Summer Sports Hydration:

Risk Factors and Prevention Strategies for High School Football Coaches and Players

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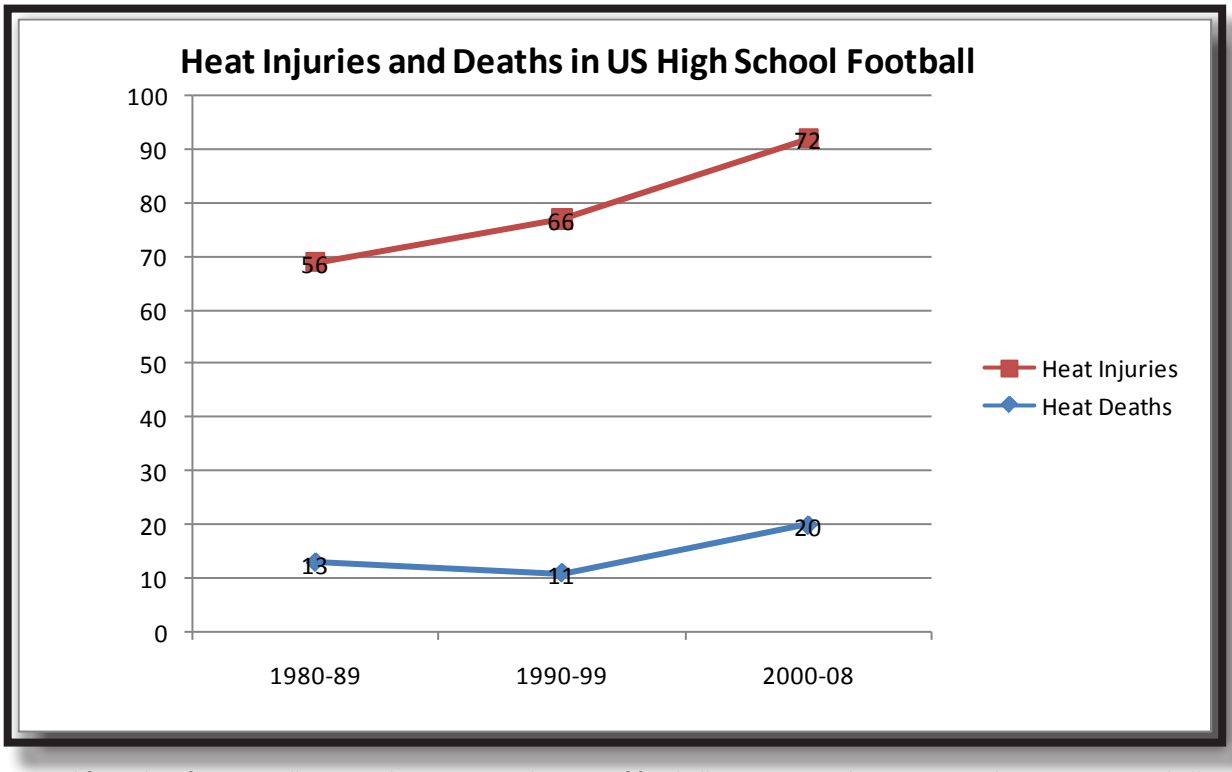
In the United States, high school football summer camps and pre-season practices occur in the hottest months of the year. This environment and various other risk factors predispose young athletes to the effects of dehydration and heat illnesses. General risk factors include body build, lack of appropriate hydration, typical practice routines, and the practice environment itself. The purpose of this paper is to define heat illnesses, delineate these risk factors in greater detail, and propose solutions easily adopted by high school coaches and players in an effort to decrease instances of heat related illnesses and possible fatalities.

Why Be Concerned?

Heat injuries are common in American high school football players and have been rising over the past three decades. In high school football players, from 1980-89 there were 56 heat injuries, 1990-99 had 66 and 2000-2008 had 72 injuries (1). The rise is similar for heat stroke fatalities (includes all levels – sandlot, high school, college, pro/semi-pro): 13 fatalities in the '80's, 11 in the '90's, and 20 in the past eight years (1). Of the 39 football players who died from heat stroke from 1995-2007, 74% were high schoolers (1). In 2008, there were six deaths in football athletes from heat stroke; four were in high school players (1). The majority of heat illnesses and fatalities occur at the high school level.



Graph created from data from: Mueller FO, Colgate B. Annual survey of football injury research 1931-2008. The American Football Coaches Association, the National Collegiate Athletic Association and the National Federation of State High School Associations 2009:1-29. Available at http://www.unc.edu/depts/nccsi/FootballAnnual.pdf. [Accessed March 29, 2009]

How Heat is Produced and Dissipated

Body heat is produced during exercise through the physiology described in Figure 1. The body's ability to dissipate heat is affected by individual metabolic and sweating rates, skin coverage by clothing or equipment, duration and intensity of physical activity, acclimation, conditioning, and the surrounding environment. Heat can be dissipated to the surrounding air by conduction (2%), convection (10%), radiation (65%), and evaporation (30%) (2). Conduction is the direct transfer of heat from surfaces that are touching. Convection removes heat by currents of air or fluids running over a warm surface. Conduction and convection

are increased with wind and decreased on still days. Radiation occurs when heat is moved from an area of higher temperature to one of lower temperature via electromagnetic waves (3). These are the "waves" of heat you see rising off playing fields in the summer. If the outside temperature is higher than 93°F, radiation from the skin is negligible and the body has to rely on evaporation (2). Evaporation occurs when a liquid (sweat), is changed to a gas. As the relative humidity rises evaporation is substantially reduced and the body is not cooled. Core body temperatures should be maintained between 97-100°F for proper physiologic functioning (4). An increase in body temperature of only 2°F beyond these levels will increase skin blood flow and heart output at the expense of other vital organs (4).

An interesting phenomenon occurs in football huddles. The "penguin effect" occurs when players in the middle of the huddle absorb heat given off by surrounding players and are unable to release this additional heat. Middle huddlers have a higher risk of heat injury and this can happen even on days when the temperature doesn't seem hot (5).

Hypohydration Defined

Hypohydration, also known as dehydration, is considered to occur with a rapid (2% or greater) loss of body weight (ie; 4 lbs for a 200 lb person) (6-7). Each person's physiology and reaction to exercising in the heat is unique, and even mild dehydration (1% loss of body weight) can lead to heat illness. Dehydration leads to a rise in pulse rate and body temperature. Increased fatigue, headaches, and decreased levels of concentration and alertness have been found at only 1-2% acute loss of body weight (8). In normal living conditions, the average daily need for water in adults aged 19-70 years is 3.7 Liters/day for men and 2.7 L/d for women with 80% of fluid intake coming from drinking and 20% from food (9). Total body water accounts for 60% of adult body weight (10) with a one liter loss of body fluid equal to a body weight loss of 2.2 lb (1 kg) (10) and a 580 kcal loss (11). Rapid weight changes (before and after practice) signal changes in body fluid (12), usually from sweating.

Sweat rates vary from player to player and day to day depending on a variety of factors listed in this paper under risk factors. In the heat, even moderate sweating can lead to dehydration. Common symptoms of dehydration are impaired physical performance (lowers stamina, focus, speed, coordination), decreased mental performance (accuracy, cognition, strategizing plays), an increase in perceived difficulty of any task, detrimental physiological effects (increases body temperature, heart rate, respiratory rate, heart strain and decreases blood pressure) and decreased blood volume and gastric emptying (7, 11, 13). Players who are dehydrated also take longer to acclimate which leads to a vicious cycle of dehydration, lack of acclimation, and further dehydration. All of this results in heat illness. A study of football players conducted by the Journal of Athletic Training found that 73% of heat illnesses were heat cramps, 21% were heat exhaustion, and 6% were heat syncope (14).

Heat Illnesses

Heat Cramps

Exercising in the heat while dehydrated can lead to cramping of the large muscles in the legs and abdomen (15). Heat cramps are due to dehydration (loss of body water), electrolyte losses (mainly sodium and chloride), and/or muscle fatigue (16). Muscle cramping first appears as a twitching of the affected muscle (most commonly calf, hamstring or quadriceps) followed by painful muscle contractions or cramping (17). Cramps are commonly seen in unconditioned players, players with a higher concentration of sodium in their sweat, and those not acclimatized to the weather (7, 17). The incidence of muscle cramping increases with higher intensity and longer duration of exercise (18). Players should be removed from the heat, stopped from exercising, orally rehydrated with water and electrolytes, and advised to watch their urine for the next 24 hours. If it turns a dark color (red, reddish brown, cola-colored) they should immediately go to the nearest emergency room. This may be a sign of rhabdomyolysis, a breakdown of skeletal muscle that releases myoglobin which can cause kidney failure.

Heat Exhaustion

Excessive sweating, fatigue, dizziness, headache, muscle aches/cramps, fainting, nausea, vomiting, and irritability are all signs of heat exhaustion (2, 19). This heat illness is due to the same causes as heat cramps (dehydration, electrolyte depletion, fatigue), but is of greater concern as it can lead to unconsciousness or heat stroke. It is often hard to differentiate from heat stroke without a rectal body temperature. Heat exhaustion core (rectal) temperature runs between 97-104°F (16). Temperatures taken in the mouth, ear, and armpit or with forehead skin strips are not reliable in this state due to vascular instability. Players with these symptoms should be removed from the heat, cooled down (remove clothes, move to air conditioned room or shade; use fans and ice bags for temperature ≥ 102°F), and rehydrated with water and electrolytes (16). If a player doesn't recover quickly, he should be taken to the nearest emergency room.

Increased fatigue, headaches and decreased concentration have been found with only 1-2% acute body weight loss

Heat Stroke

Heat stroke is a medical emergency. The term "heat syncope" is often used interchangeably with heat stroke. Signs include any of the heat exhaustion symptoms along with a high core body temperature (>104°F) and altered mental status (strange behavior, confusion, disorientation, poor judgment) (19). Later symptoms include anhydrosis (inability to sweat), shock, irregular heart rhythms, fluid in the lungs, seizures, and coma. Despite the possibility of experiencing anhydrosis, greater than 50% of these victims do sweat (2). Lack of sweat is usually a late sign and cause for alarm. Rapid cooling on the field must be initiated and immediate transport to a hospital is critical. Treatment on the field includes placing the player (remove clothes and equipment) in a plastic kiddie pool filled with cold water (35-59°F) while awaiting the ambulance and checking core temp every 5-10 minutes is crucial (16). If a pool is not available, ice bags in the armpits, groin, and neck, and wet cool towels on the trunk and extremities with fanning will help. When the player's core temperature drops to 101-102°F, remove him from the pool to avoid overcooling. Risk of death is higher the longer the core temperature is above 106°F (16) so cooling must continue even during transport. Advanced medical care is critical. Because the symptoms of heat exhaustion and stroke are so similar, if there is any doubt about a player's condition err on the side of safety and have them transported to the nearest hospital.

Hyponatremia

A low sodium level in the blood (<135 mmol/L) is called hyponatremia. It occurs with heat exercise and is due to excessive drinking of water or loss of salt through a player's sweat. When players consume plain water in amounts greater than sweat losses their plasma becomes diluted which drops their sodium level. It also occurs when a player has a high concentration of sodium lost in their sweat or sporting events last longer than three hours (15). Acute hyponatremia is more dangerous than dehydration because it can rapidly induce a coma or death (7). Rectal temperature is usually < 104°F (16). Differentiating hyponatremia from heat exhaustion or stroke can be tough since taking a rectal temperature on the field is difficult. The main point is not to differentiate, but to get these players immediate medical attention. Symptoms include nausea, vomiting, headache, decreased consciousness, lethargy, confusion and seizures. Any change in mentation or behavior is a red flag to call an ambulance and rapidly cool down the player.

Risk Factors

Any factor that increases the production of body heat or decreases the body's ability to rid itself of the heat generated can lead to dehydration or end in heat stroke (7). These risk factors can be separated into environmental, practice, and individual factors for football.

Environmental Factors

Heat and Humidity

The number of heat illness cases increase as the outdoor temperature and relative humidity rise (8). The universally accepted way of monitoring this is by the Wet Bulb Globe Temperature (WBGT) Index. This index is derived from a formula combining three readings: WBGT Index = 0.1 (ambient air temperature) + 0.7 (humidity) + 0.2 (radiant heat). The reading is then compared to a chart for depicting dangerous weather days for exercising (Figure 2). A free program for converting local temperature and humidity data to WBGT is available online at: http://www.zunis.org/sports_p.htm. This program can be downloaded to a computer or PDA. Wet bulb globe thermometers are available online for $105.

While it doesn't include the radiant heat factor, use of a heat index chart is free, readily available, and simple to use (http://www.crh.noaa.gov/jkl/?n=heat_index_calculator). Using this chart (Appendix A), if the ambient temperature is 96°F (a common summer temperature in the Midwest) and the relative humidity is 50%, the heat index (how hot it feels to the human body) is a temperature of 108°F. If the relative humidity is increased to 70%, the 96°F temperature now becomes a heat index of 126°F. The chart delineates days of caution.

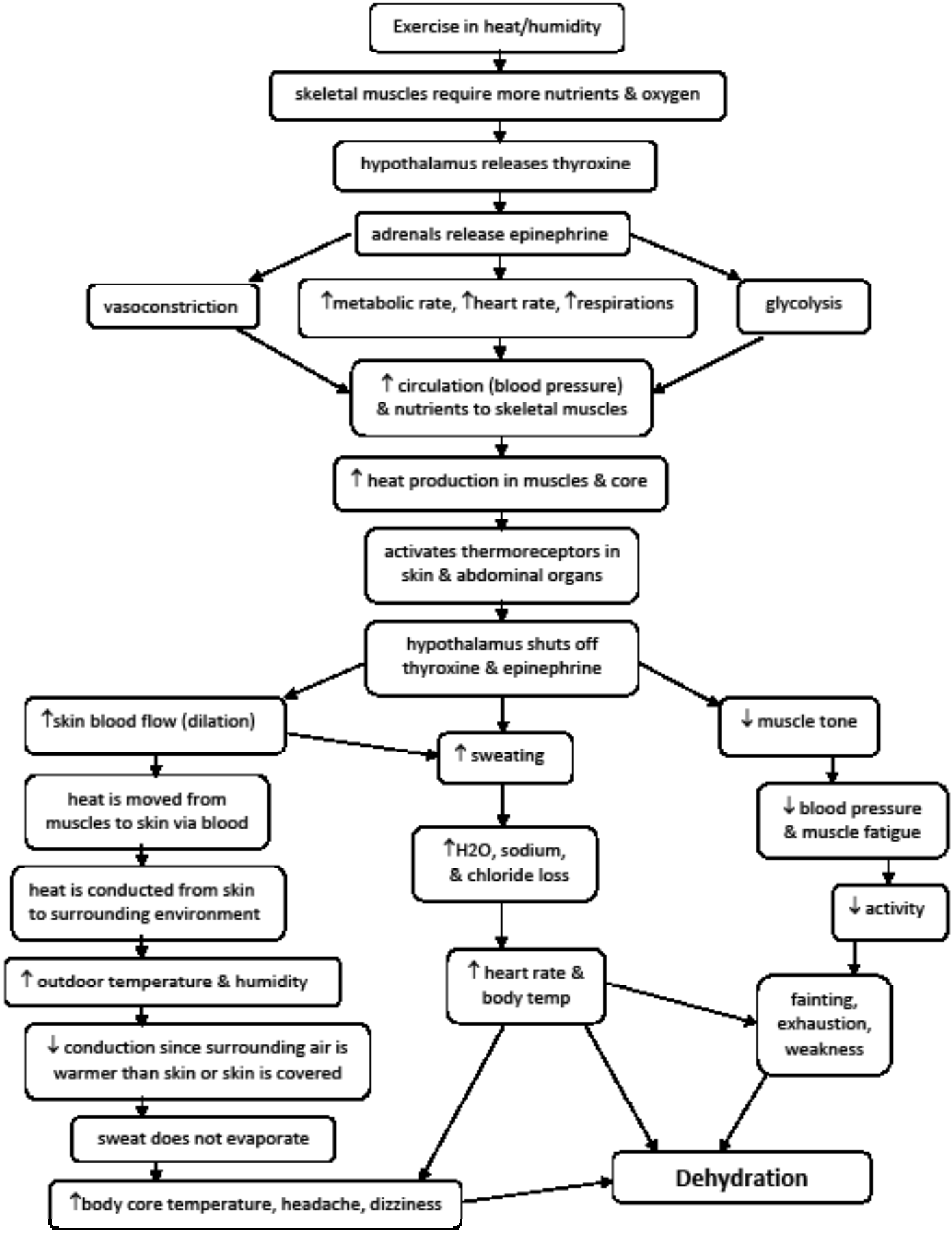
WBGT	Level of Risk	Comments
<65°F	Low	Risk low but still exists
65-73°F	Moderate	Risk level ↑ as practice progresses through the day
73-82°F	High	Heat injury potential is high; players at risk should not play
>82°F	Extreme/hazardous	Delay or reschedule practice. If event must occur, be on high alert.

Figure 2. Wet-Bulb Globe Temperature Risk Chart (adapted from Binkley HM, Beckett J, Casa DJ, Kleiner DM, Plummer PE. National Athletic Trainer's Association position statement: exertional heat illnesses. *Journal of Athletic Training* 2002;37(3):329-343)

Heat and humidity are at their highest in the Midwest during the summer when camps and preseason practice occurs. In college players, the majority (96%) of heat illnesses happened during preseason practices (20) with the first three weeks in August having the highest risk (14). As dehydration increases during exercise in the heat so does the body's core temperature (15). Murray found that with only modest heat stress (> 60°F), strain on the heart increases and makes the level of hydration critical in maintaining blood pressure and flow to the muscles and brain (6).

Accessing online data from the National Oceanic & Atmospheric Administration (NOAA) for the Spirit of St. Louis Airport in the months of August 2006, 2007, and 2008, wet bulb globe temperatures were mostly in the high level of risk category for mid-August preseason practice dates (Appendix B). This means that the potential for heat injury is high and players at risk should not play (16). Looking at the same data for hourly temperatures on two days (August 15, 2007 and 2008), the coolest time of the day occurred before 8 am

Figure 1. How Heat is Produced and Dissipated During Exercise



with a return to 8 am temperatures not occurring again until 9 pm (Appendix B). The hottest time of the day happened between 12 to 7 pm (Appendix B). This emphasizes the need for early morning practices and caution when exercising during the afternoon.

Synthetic Turf vs. Grass

While natural grass has its drawbacks (potholes, rocks, muddy when wet, and inability to use), synthetic turf can not only add to player injury, but also increase the risk of heat illness. Games played on turf have 10% more injuries, a higher possibility of ingesting chemical particulates from the rubber infill, a greater number of turf burns that increase the probability of infection (especially methicillin-resistant staph aureus), and are significantly hotter than natural fields (summer surface turf temperatures can reach 160°F and run 60°F hotter than grass) (21). Even moderately warm days can cause turf fields to be very warm. A study done in July 2007 with an outdoor temperature of 78°F measured the grass field temperature at 85°F and the turf at 140°F (21).

Artificial Turf

- **Causes 10% more injuries**
- **Increases skin infections**
- **Can reach 160°F in the summer**

Practice Factors

Lack of Acclimatization to Heat and Sequential Training

Lack of acclimatization to heat is one of the primary factors in heat illness. Proper acclimatization takes about 7-15 days for the human body (8, 13, 14, 16). Sequential practicing, day after day, with two sessions a day leads to loss of body fluids (22) and doesn't allow enough time between sessions for full rehydration. Thus, players may already have a fluid deficit from the previous practice or the day before (7). A player can become severely dehydrated after several days of mild to moderate dehydration add up.

Intensity and Duration of Practice

Intensity (amount of exercise time compared to break time in an hour) and length of practice are important considerations. Two practices per day, each practice lasting more than 3 hours, and little time off in between practices increases hypohydration and the incidence of heat stress (14).

Insulation of Uniforms/Equipment

Typical football equipment includes the wearing of a helmet, shoulder/chest pads, possible rib cage pads (quarterbacks), neck-protective collars, jersey, padded pants, knee-high socks, padded gloves, and cleats. Since the majority of heat dissipation comes from sweat evaporation, this excessive covering of the skin's surface leads to higher heat retention. Clothing and pads can also increase the humidity in the area surrounding the skin and thus create a barrier to sweat evaporation (23). McCullough tested five football uniforms (3 NCAA full game + 2 practice) in still-air conditions using electric mannequins (Table 1). The G3 (cold weather uniform) provided almost three times more insulation than the practice uniform (P1) which provided twice the insulation as the t-shirt and shorts (control reference) (24). The G2 (regular uniform) and G3 had three times the evaporative resistance compared to the t-shirts and shorts (24). Even the minimal uniform allowed (G1, warm weather) decreased dry heat loss by 42% (24). A full uniform (NCAA regulation)

covers 50% of the body's surface (8), almost triples heat insulation, and decreases the evaporation of sweat by two-thirds (25).

TABLE 1. Configurations of football uniforms tested.[a]

Uniform	G1. Game Uniform (Warm Weather)	G2. Game Uniform (Temperate)	G3. Game Uniform (Cold Weather)	P1. Practice Uniform (with Hip Girdle)	P2. Practice Uniform (Shorts Only)
Upper body	Helmet + chin strap Shoulder pads Sleeveless cut-off T-shirt Short-sleeved mesh jersey (tucked into pants)	Helmet + chin strap Shoulder pads Long-sleeved knit shirt Short-sleeved knit jersey (tucked into pants) Gloves	Helmet + chin strap Shoulder pads Thick long-sleeved shirt Short-sleeved knit jersey (tucked into pants) Gloves	Helmet + chin strap Shoulder pads Sleeveless cut-off T-shirt Short-sleeved mesh jersey (cut off at waist and hanging loose)	Helmet + chin strap Shoulder pads Sleeveless cut-off T-shirt Short-sleeved mesh jersey (cut off at waist and hanging loose)
Lower body	Jock strap Hip girdle with hip, thigh, and tail bone pads Football pants with knee pads + belt Ankle-length socks Turf shoes	Jock strap Hip girdle with hip, thigh, and tail bone pads Football pants with knee pads + belt Knee-length socks Turf shoes	Jock strap Hip girdle with hip, thigh, and tail bone pads Knit long underwear Football pants with knee pads + belt Knee-length socks Turf shoes	Jock strap Hip girdle with hip, thigh, and tail bone pads Mesh shorts Ankle-length socks Turf shoes	Jock strap Mesh shorts Ankle-length socks Turf shoes

[a] A reference ensemble consisting of a T-shirt, briefs, shorts, ankle-length socks, and athletic shoes was tested for comparison also.

Table 1. Five Different Football Uniform Configurations (NCAA full game uniforms: G1, G2, G3. Practice uniforms (no regulations): P1, P2) (From McCullough EA, Kenney WL. Thermal insulation and evaporative resistance of football uniforms. *Medicine & Science in Sports & Exercise* 2003;35(5) p. 833.

Player Factors (Individual)

Adolescent vs. Adult

Adolescents are at greater risk for dehydration and hyperthermia because they produce less sweat per sweat gland, have fewer glands, are less able to transfer heat from their muscles to the skin, have a smaller cardiac output which reduces internal heat transfer to the skin, and they acclimatize slower than adults (a teen may take 5-6 sessions to an adult's 2-3 sessions) (26).

Preexisting Level of Fitness

Many football players are not aerobically conditioned. To keep toned, footballers tend to do weight-lifting and plyometrics in the offseason in an air-conditioned gym (27). This does not allow them to acclimate to the outdoor heat, nor does it provide adequate aerobic fitness. Unconditioned players will suffer from the effects of hypohydration at a faster rate and an increased level of intensity. These players also tend to be larger in size and weight, and have a greater body fat percentage (27).

Large Body Size (High Body Mass Index)

Heavier players have more difficulty dissipating heat and are, therefore, more prone to heat stress. Additionally, lean body tissue holds predominantly more water than fat body tissue which places obese players at an even higher level of risk. A 220 lb obese male adult has 30% of his total body weight in water; a 220 lb lean adult male has seventy percent (10), so an obese male will dehydrate quicker. Obese players have a larger body mass to surface area ratio (8) so they have fewer sweat glands to dissipate heat. Increased levels of fat will lead to faster gains in heat (23) and greater heat retention causing these players to become hyperthermic much faster than their leaner counterparts(26). Heavily muscled players also have a higher body mass to surface area ratio and greater metabolic heat production (16) making them more susceptible to heat injury.

Body weight and height varies with the sport and the position played. Cross-country runners often weigh 143-165 lbs. while professional linemen weigh 259-319 lbs (27). College offensive linemen average weight runs between 291-316 lbs, linebackers averaged 220-238 lbs, and tight ends and defensive tackles

averaged 266-291 lbs (8). Malina studied young football players aged 8.7-14.6 years and found that 45% were classified as overweight or obese by CDC criteria (28). The body mass index (BMI) is used to classify overweight and obesity levels. BMI = weight in lbs/height in inches^2 X 703. A BMI of 25-29.9 is considered overweight and ≥ 30 is obese. The average BMI for players who developed hyperthermia (>102°F) at practice end was 34.2 (8) and male players with a BMI of 0.22/kg/m^2 had an eightfold greater incidence of heat stress than leaner, fitter players (29). Heavier players induce a higher workload on their cardiovascular system and experience more heat-related illness.

Voluntary Hydration

Normally, thirst works well as a physiologic mechanism to replace lost fluids. However, several studies have shown that adolescents' fluid replacement is insensitive to heat and exercise stress conditions (12), and both inconsistent and insufficient to restore water balance if left to drinking purely on a voluntary basis (22-23). Most studies show that athletes only voluntarily replace 50-66% of their actual fluid needs (11). There was also no significant connection found between thirst and WBGT (8), meaning heat and humidity did not increase drinking.

Gastric Emptying Rates

The rate of how quickly a player's stomach empties itself of fluids can affect how much they drink. Exercising with a full stomach can also cause nausea and further limit fluid intake. During a game, the gastric emptying rate is likely to be decreased and the risk of gastrointestinal discomfort increased (30) due to increased exercise, heat, and metabolic rate. Stomach emptying rate varies widely, but maximal gastric emptying exceeds 1.3 liters per hour (6). Stomach volumes increase and gastric emptying rates decrease with the ingestion of drinks that contain ≥ 8% carbohydrates (31).

Summer football players in full gear can have sweat losses > 8 liters per day. Sweat loss in the average person is just over one-half liter/day.

High Sweat Rates ↑ Fluid Losses

When exercised, muscles produce heat that has to be dissipated through the skin by sweating. The majority (80%) of heat loss during exercise is from sweating (11). Sweating causes a loss of fluid volume from the body's central circulation that in a normally hydrated player can be compensated for (up to about a loss of 2% body weight) by the movement of tissue fluid into the bloodstream (32). An adult's average daily liquid intake is 1300 ml for oral fluids, 1000 ml for water in food, 300 ml for water from body metabolism (10). Daily output is approximately 1500 ml from urine, 600 ml from skin, 300 ml from respirations, and 200 ml from stool (10). Sweat loss combined with low liquid ingestion leads to a reduced blood volume which decreases blood flow to the skin. This decreased blood flow lowers sweat production and prevents the body from removing heat which in turn leads to cardiovascular strain and heat illness. A balance between intake and output is vital to the prevention of dehydration and hyponatremia.

Fluid loss from heat-exercise varies greatly among players due to the previously listed risk factors. Several studies have shown that sweat loss in this environment can range from 1.3-3.45 liters/day (12), averaging >2 liters/day (27). Summer football players wearing full gear can have sweat losses >8 liters/day (7). Sweat loss in the average person is approximately 600 ml and when it increases to 1300-3450 ml, heat illness and dehydration occur. A study of Australian rugby players showed that fluid losses of as little as 1% could affect thermoregulatory responses and deficits of 3% can significantly decrease the body's capacity to work (22). Furthermore, respiratory rates increase with exercise (more so in unconditioned or obese players) causing an additional loss of fluid from the lungs, often exceeding 300 milliliters.

TABLE 2. Observations of sweat rates, voluntary fluid intake and levels of dehydration in various sports. Values are mean, plus (range) or [95% reference range].

Sport	Condition	Sweat rate ($L \cdot h^{-1}$) Mean	Sweat rate ($L \cdot h^{-1}$) Range	Voluntary fluid intake ($L \cdot h^{-1}$) Mean	Voluntary fluid intake ($L \cdot h^{-1}$) Range	Dehydration (% BM) (= change in BM) Mean	Dehydration (% BM) (= change in BM) Range
Waterpolo [41]	Training (males)	0.29	[0.23–0.35]	0.14	[0.09–0.20]	0.26	[0.19–0.34]
	Competition (males)	0.79	[0.69–0.88]	0.38	[0.30–0.47]	0.35	[0.23–0.46]
Netball [16]	Summer training (females)	0.72	[0.45–0.99]	0.44	[0.25–0.63]	0.7	[+0.3–1.7]
	Summer competition (females)	0.98	[0.45–1.49]	0.52	[0.33–0.71]	0.9	[0.1–1.9]
Swimming [41]	Training (males & females)	0.37		0.38		0	(+1.0–1.4 kg)
Rowing [22]	Summer training (males)	1.98	(0.99–2.92)	0.96	(0.41–1.49)	1.7	(0.5–3.2)
	Summer training (females)	1.39	(0.74–2.34)	0.78	(0.29–1.39)	1.2	(0–1.8)
Basketball [16]	Summer training (males)	1.37	[0.9–1.84]	0.80	[0.35–1.25]	1.0	[0–2.0]
	Summer competition (males)	1.6	[1.23–1.97]	1.08	[0.46–1.70]	0.9	[0.2–1.6]
Soccer [130]	Summer training (males)	1.46	[0.99–1.93]	0.65	(0.16–1.15)	1.59	[0.4–2.8]
Soccer [89]	Winter training (males)	1.13	(0.71–1.77)	0.28	(0.03–0.63)	1.62	[0.87–2.55]
American football [62]	Summer training (males)	2.14	[1.1–3.18]	1.42	[0.57–2.54]	1.7 kg (1.5%)	[0.1–3.5 kg]
Tennis [15]	Summer competition (males)	1.6	[0.62–2.58]	~1.1		1.3	[+0.3–2.9]
	Summer competition (females)		[0.56–1.34]	~0.9		0.7	[+0.9–2.3]
Tennis [14]	Summer competition (cramp–prone males)	2.60	[1.79–3.41]	1.6	[0.80–2.40]		
Squash [18]	Competition (males)	2.37	[1.49–3.25]	0.98		1.28 kg	[0.1–2.4 kg]
Half marathon running [21]	Winter competition (males)	1.49	[0.75–2.23]	0.15	[0.03–0.27]	2.42	[1.30–3.6]
Cross–country running [62]	Summer training (males)	1.77	[0.99–2.55]	0.57	[0–1.3]	~1.8	
Ironman triathlon [133]	Temperate competition (males & females]						
	Swim leg					1 kg	(+0.5–2.0 kg)
	Bike leg	0.81	(0.47–1.08)	0.89	(0.60–1.31)	+0.5 kg	(+3.0–1.0 kg)
	Run leg	1.02	(0.4–1.8)	0.63	(0.24–1.13)	2 kg	(+1.5–3.5 kg)
	Total race			0.71	(0.42–0.97)	3.5%	(+2.5–6.1 %)

+ = gain in BM; ^not corrected for change in BM that occurs in very prolonged events due to factors other than fluid loss (e.g. metabolic fuel losses).

Table from Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. Exercise and fluid replacement. American College of Sports Medicine. *Medicine & Science in Sports & Exxercise 2007*; Position Stand:377-390.

$$\text{Sweat rate} = \frac{\text{pre-exercise body weight - post-exercise body weight + fluid intake - urine output}}{\text{exercise time in hours}}$$

By using this equation, Godek found that sweat rates and losses were greater in football players (2.14 liters/hour) than those experienced by cross country runners (1.77 L/hr). Additionally, the footballers required an intake of 12.2 liters/day, with 2.9 liters ingested immediately after practice, compared to 4.6 L/d, with 0.7 liters immediately, for the runners (27). The range for liquid replacement in the footballers was from 8.8 – 19.0 liters/day (27). As a sport, football has the highest sweat rate and dehydration percentage of all sports (Table 2).

High Sweat Rates ↑ Sodium and Chloride Losses

The average amount of sodium lost in human sweat is 4-50 mmol/liter (6). In professional football players this can range from 68-110 mmol/liter (27). For example, a sweat loss rateof 2.5 L/d at a concentration of 4-50 mmol/L would lead to a loss of 5.75-7.2 grams of sodium (6). An average pro-football player with a daily sweat loss rate of 9.4 L, at a sodium concentration of 50 mmol/L, would lead to a loss of over 10 grams of sodium/day (27). Non-acclimated players, heavy sweaters, and sweaters with high salt concentrated sweat lose more sodium chloride which predisposes them to heat illness (16).

D**ehydrated Before Practice & Accumulated Dehydration**

Studies of football and rugby players have demonstrated that players are often inadequately hydrated as noted by pre-practice measurement of urine specific gravity (the concentration of fluid to solutes in urine) (18, 27). A player who is slightly dehydrated the first day of practice, doesn't rehydrate adequately, and attends practice the second day in this state will become increasingly dehydrated as the week goes on (7). This cumulative hypohydration can amount to 5-8% of body weight (33). It takes 48 hours to replace intracellular fluids after 2-3 days of progressive dehydration (33). Exercise-induced heat illness often occurs soon after beginning practice, correlates with the preceding days' hypohydration, and arises at a lower ambient temperature for the hypohydrated than the euhydrated (29).

Preexisting Condition or Illness

Preexisting medical conditions, concurrent illness, or the use of medications can affect the propensity to develop heat illness. Montain found several epidemiological studies that showed 16-18% of heat stroke patients were sick on the days before the incident (29). Colds that are associated with a fever, intestinal and stomach viruses that cause vomiting and/or diarrhea, and any illness that decreases appetite or hurts the throat will cause a player to be dehydrated before practice and prone to greater hypohydration during practice. Strep throat and other infectious illnesses are common in the teen years. The US Food and Drug Administration states that the peak incidence of Ebstein-Barr virus (mononucleosis) is 15-17 years. Mono not only has the dehydration/heat illness aspect it also has the problem of possible rupture of the spleen with minimal or no contact during football practice. Previous history of heat-related illness raises a player's likelihood of experiencing another one (27).

Preexisting conditions such as asthma, diabetes, sickle cell trait, migraines, and attention deficit hyperactive disorder (ADHD) can predispose the athlete to heat stress. According to the American Lung Association in 2006, asthma affected 15% of children aged 5-17 years. Asthma and diabetes are increasing at epidemic rates amongst today's youth. Diabetics should exercise, but they don't recover from exercise as quickly which can cause hypoglycemia (low blood sugar), fatigue, and delayed recovery before the next game (34). Many footballers are African-American and thus may have sickle cell trait which can decrease their blood flow and oxygen-carrying capacity (16) and increase their risk of heat injuries. Finally, teenage football players often don't want to speak up about how they feel for fear of being labeled a wimp.

Medications

Use of medication can have various effects depending on the condition and the drug. Use of diuretics to meet a weight classification is common in wrestlers and footballers and can lead to pre-exercise dehydration (7). Use of performance-enhancing supplements such as anabolic steroids and stimulants will lead to heat intolerance. A 2006 drug testing study of 60 U.S. high schools showed a 16.6% use of the stimulants amphetamine, pseudoephedrine, cocaine, Ecstasy and phentermine (listed in order of greatest use) (35). The majority of ADHD medications are stimulants. Even over-the-counter cold medications such as pseudoephedrine, Neosynephrine, and anti-cholinergics (block the sweating response, dry the mouth) can hasten dehydration.

Supplements

Protein supplements, including creatine, are widely used by young athletes, especially football players. A study of 12th grade athletes showed a 44% use of creatine, an increase from 2.1% in 7th grade (26). Creatine doses > 2 grams/day are useless (the body synthesizes 2 grams/day) and harmful (35). While it seems safe, protein ingested at the doses recommended on supplement products puts a significant solute load on the kidneys and liver because it takes almost seven times more water to metabolize body protein than fat or carbohydrate (26). Excessive protein intake (for 14-18 year olds >0.85 grams/kg of body weight)(36)combined with the dehydration that occurs during preseason practice, places the kidneys at risk for acute failure (35). From a performance standpoint, superfluous protein intake will replace carbohydrate intake. Carbohydrates are necessary for peak training and competition levels as they are the main fuel source during practice (26). High protein levels cause loss of calcium in the urine (26) which may lead to improper bone formation. Protein replacement after exercise is acceptable and will aid in the rebuilding of muscle tissue, but should not be excessive. However, the supplement of choice of this generation is the energy drink.

Ingestion of Energy Drinks

Energy drinks are often consumed by teens before practice and games as they are touted to improve exercise performance, endurance, and reaction times. Use of energy drinks starts at an early age with 28% of 12 to 17 year-olds imbibing and increasing to 34% of those aged 18 to 24 years (37). Luke did a survey of 540 US high school football programs from 26 states and found that 45.2% of players used energy drinks (38).These effects are due mainly to caffeine, taurine, glucuronolactone, and guarana; ingredients that are not currently regulated by the FDA and whose amounts are often not listed on the product container. Taurine is an amino acid that is rapidly absorbed with a half-life of 35 minutes (39). It is a mood modulator and combined with caffeine and guarana is responsible for increasing physical endurance to a certain extent. There is not much data on glucuronolactone, but it has a long action within the human body with peak levels at five hours. It is thought to provide extra energy when combined with the other ingredients. Guarana is a stimulant that contains not only caffeine (3-5 grams of guarana equals about 250 mg of caffeine), but also theobromine, theophylline and tannins which may increase the length of action of guarana (40).

For reference, a cup of coffee has approximately 100 mg of caffeine and a cup of Coke has 34 mg. Energy drinks contain from 80 mg (Red Bull) to 400 mg (Fixx Extreme) caffeine per serving. A complete list of the caffeine amount in beverages can be found at: http://www.energyfiend.com/the-caffeine-database%20. According to a study by the American Society of Addiction Medicine, caffeine intoxication can occur with doses of only 500 mg (37). Caffeine toxicity can cause fast abnormal heart rhythms, seizures, profound vomiting, and high blood pressure (40). In addition to these very negative effects, caffeine is also a diuretic. In small doses (< 180 mg/day) (7) and moderate doses (<300 mg/d)(15), it generally doesn't cause dehydration during exercise. However, combining it with the other stimulants and/or alcohol (a diuretic in high amounts) and

ingesting them on a hot, humid day can lead to a hypohydrated state with a fast heart and respiratory rate, and a concomitant drop in blood pressure.

Ingestion of Alcohol

According to the CDC's 2007 Youth Risk Behavior Survey of male 9th-12th graders in the state of Missouri: 44.4% of students were current alcohol users, 30.1% were episodic heavy drinkers, and 72.3% had tried alcohol (41). Alcohol in large amounts is a diuretic (7), but more importantly, it can be toxic to the system and cause severe vomiting. High school football players who party the night before a practice or game may be moderately to severely dehydrated before workouts and are predisposed to heat illnesses and low potassium.

PRACTICAL SOLUTIONS

Solutions must be easily accomplished to be used on a regular basis. Suggestions for decreasing the risk factors of heat stress are grouped as practice environment, individual player practices, and suggestions for coaches, trainers and parents.

Practice Environment

Institute an Acclimatization Period

Allowing the human body to physiologically adapt to the increased outdoor temperature and humidity is integral to preventing heat illness. Heat exercise acclimatization takes about 7-10 days (8). Reducing the duration and intensity of practice during the initial 2-3 weeks will help promote heat tolerance in conditioned athletes (23, 38) and prevent adverse effects in unconditioned players since most heat stroke deaths occur in the first four days of practice (42). The overall consensus for a high school football acclimatized practice schedule is (8, 20, 42):

- One practice not to exceed 3 hours, no live contact (Days 1-6)
- Practice includes warm-up, conditioning, instruction, breaks, and cool-down
- Conditioning should not exceed 60-90 min/day (Days 1-6)
- May use blocking sleds and tackling dummies (Days 4-6)
- Helmets only (Days 1, 2), helmets & shoulder pads (Days 3, 4, 5), full pads (Day 6)
- No more than 6 sequential days of practice
- Alternate two-a-day (5 hours combined total with 3 hours off between practices) with one-a-day (3 hours) practices, full pads (Days 8-13)
- Scrimmages should not begin before Day 12
- Modify practice daily according to heat/humidity/radiation

On extreme weather days move the practice indoors (view films, go over plays, do conditioning exercises, run drills in gym) (42) or to a cooler time of day (early morning). Be aware that players with sweat patterns only on the forehead and chest triangle down to abdomen may not be completely acclimated (13) as fully acclimated players will sweat over their entire body.

Change Practice Environment

Practice on a natural grass, not synthetic turf, field. Utilize any shaded area on or near the practice field for rest breaks to reduce radiant heat load (42). If none is available, have a large open tent to shade players or have 1-2 sprinklers flowing at the edge of the field for players to run through to cool core temperature and skin surface. These can be placed on a stopcock valve so that they do not overly wet the field edge and destroy the playing surface. Misting tents can be purchased online and set up on the parking lot near a storm sewer drain so as not to damage the field. Another simple and cost-effective alternative is to fill two plastic "kiddie" pools with ice water. These pools will be critical in lowering core temperature if any player suffers from heat

exhaustion or stroke. Additionally, field temperature and humidity should be monitored before and during practice on a regular basis (38).

Rest Periods to Cool Down

Frequency and length of breaks should be based on the players' conditioning levels and the climate. Regular breaks should occur several times an hour (42) with enough time to fully cool down, rest, and drink enough fluids. In healthy fit young athletes after 80 minutes of demanding exercise in the heat, it was found that 1 hour of rest, cooling, and rehydration eliminated any residual or carryover effects (43). During 60 minutes of conditioning exercise in the heat, it is good practice to break every 15-20 minutes (38).

Decrease Skin Coverage

To allow evaporation and convection of exercise-induced heat production free up a larger portion of skin surface area. Progressively add equipment over a period of days (as suggested earlier) to allow acclimatization. Practicing in shorts, shoulder pads, jersey and helmet (half uniform) only doubled the heat insulation, and cut the sweat evaporation by half (25). Fish-net fabric allows greater air circulation (23) and light colored clothing can block reflective heat (16). Remove helmets whenever possible to dissipate heat (42). A football helmet that radio transmits a player's temporal artery temperatures between 99-110°F every ten seconds to a PDA monitored by the coach is available from Hothead Technologies (55). This new high-tech helmet allows heat-affected players to be removed from the field before heat illness develops.

Figure 3. Waterboy Onfield Hydration System

Pre- and Post-Exercise Body Weights

Measuring pre- and post-practice change in body weight is a reliable way to assess how much fluid a player needs to replace (38, 44). Coaches should require that players weigh themselves before and after practice to determine their average daily fluid loss. This requires that players have some idea of the amount of fluids they have ingested during practice. Weights should be done at the same time daily, without sweaty clothes (preferably nude), and recorded on a wall chart. The difference between pre- and post-exercise weights minus the fluids consumed during exercise should be calculated along with the fluid needed for replacement.

Offer Hydration on the Field

Water should be available in several sites on the field and offered in a way that will allow players to easily drink what they need. Larger quantities of cold fluids are more readily consumed by hot athletes (7, 42). Thus, the use of a battery cooled water system with multi-player access like a Waterboy (www.waterboysports.com) is a good idea (Figure 3). Costs of various hydration units from Waterboysports vary from $125-1700. If recording fluid intake, the use of 8 ounce cups or bottles will allow the player to keep track of the quantity consumed.

Closely Monitor At-Risk Players

Players that are overweight, unconditioned, partially dehydrated, ill, taking medications or have a medical history are at greater risk. Linemen (guards, centers, tackles) are usually the largest players, often overweight, and unconditioned to the heat. Football players also tend to have a "warrior" mentality so they won't stop when they are feeling ill; they "play through it." Sequential practices and those occurring on a weekend (after a night out) should bring to the mind the possibility of cumulative dehydration.

Medications such as over the counter anti-cholinergics (antihistamines, antidepressants, and acid reflux drugs to name a few) have been linked to serious heat illness, and macrolide antibiotics, decongestants, methylsanthines (asthma drugs), and beta-agonists (asthma drugs) have been associated with irregular heart rhythms (45). Attention deficit hyperactive medications, diuretics, and urine concentrations of caffeine exceeding 15 micrograms/ml are banned, with good reason, at the college and international level by the NCAA. A banned drug list is available at www.ncaa.org.

Conditions such as asthma, obesity, diabetes, sickle cell trait, insect allergies, and heart problems are rising in incidence and require special care because heat exercise can cause earlier and more severe symptoms. Football players with medical conditions should have a buddy-player who knows where their insulin, epinephrine pens, or asthma inhalers are kept and how to use them. Medications should be stored in a small cooler on the field in plain sight or carried by the coaches. Sustained sprints (> 500 meters) and timed miles should not be required of players with sickle cell trait; muscle cramping in these players should be considered and treated as sickling (42) and they should be taken to the hospital. Exerting activities carried out by diabetics may lead to hypoglycemia (sweating, palpitations, confusion, lethargy, difficulty with speech, loss of coordination, nausea, and headache) which mimics heat exhaustion. Young diabetics who exercise for > 90 minutes may need to decrease their insulin dose by 70-80% to prevent hypoglycemia (34). Rapid oral intake of orange juice will help to initially treat low blood sugars. Players who previously had a heat illness are more likely to experience it again. Those who are currently sick (mono, strep throat, vomiting, diarrhea, bad head cold) should stay home or be sent home.

Require Pre-Play Physical Exam and Player Health Record

All players should have an up-to-date physical exam (PE) on record and coaches should review each player's PE noting any major risk factors. Rhode Island is the only state that does not require a pre-play exam of high schoolers (45). Missouri state law requires an annual PE prior to participation in secondary school sports. However, in reviewing three local school district's PE forms (Appendix C) there is a lack of information on conditions that predispose a player to heat illnesses and this correlates with previous studies on the ineffectiveness of the PE in preventing heat injury (38). Having a player answer questions pertinent to these issues can pinpoint those future students who would suffer heat injury. I have developed a form (Figure 4) that can be used as an addendum to the PE that outlines risk factors for heat illness. The American Academy of Pediatrics has listed two definitive "No's" to sports participation -- inflammation of the heart (carditis) and fever (>100.4°F) and a qualified "no" – diarrhea based on increased dehydration and heat illness risk.

Figure 4.

Player Health Record

Name/Age:_____

Circle any of the below that you have experienced in the past or have now:
ADHD or ADD
Allergies (hay fever/food/mold-dust/other)
Asthma
Bee or insect sting reaction
Cold, flu, stomach virus
Diabetes
Fainting
Headaches
Heart condition
Heat illness
Kidney condition
Mono or Strept throat
Muscle cramps
Seizures
Sickle cell trait/disease
Other:_____

Circle any you take:
ADHD/ADD medications
Antibiotics
Antihistamines
Caffeine, Guarana, Taurine
Decongestants/ Neosynephrine
Diabetic medications
Diuretics
Ephedrine, phenylephrine, pseudoephedrine
Epinephrine pen for insect sting
Heart medicine
Inhalers for asthma or allergies
Oral medication for asthma or allergies
Protein supplements/Creatine
Tobacco (inhaled or chewed)
Other:_____

Do you exercise outside of school sports?
Yes
No

When you exercise, what do you do the most:
Weight lifting
Running indoors
Running outdoors
Using resistance machines
Don't exercise outside of school sports

When you exercise, is it mostly done:
Indoors
Outdoors
Don't exercise outside of school sports

Is this exercise done:
All year long
Seasonally

In the summer heat, during a 1 week period, how often are you outside either working or exercising that causes you to sweat?
½ hour
1-2 hours
3-5 hours
6 or more hours

During football camp or preseason practice, how often do you drink fluids:
About every 15 min
About every 30 min
About every hour
Don't drink until done

During camp or practice, how much do you drink each time you drink:
2-3 swallows
About a ½ cup
About a cup

During camp or practice, what do you drink:
Energy drink
Sports drink (Gatorade, Powerade, etc)
Water from the Waterboy on field
Water that I bring in a bottle
Vitamin water
Don't drink until done

What do you mostly eat for breakfast before camp/ practice (circle all that apply):
Cereal and milk
Coffee drink
Eggs, toast
Energy drink or bar
Protein shake or bar
Don't have time to eat
Don't eat because I don't want to feel sick

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Individual Player Practices

Don't be a Gladiator

Athletes should know their limits, medical issues, and how their bodies react in the heat under physical stress. Players should be assertive and vocal when reaching a limit. Each player should have a buddy who will not only watch over him, but also make him take a break when necessary.

Condition Yourself

In the weeks preceding summer camp or preseason practice, football players should step out of the air-conditioned gym and begin the acclimatization process. Outdoor exercise beginning with 15-20 minutes/day and increasing by 5-10 minutes daily (25) starting several weeks before camp is a good practice.

Monitor Weight and Urine Amount/Color

Since each player's sweat loss is unique, the best practice is to first establish their percentage of dehydration by weighing (%dehydration = [(Pre-practice body weight – post-practice body weight)] x 100/ pre-practice body weight) (18, 22, 32, 38), taking the average over a period of a week, and replacing fluids accordingly (1 L for every 2.2 lbs lost). To reflect the true hydration state, urine color should be checked first thing in the morning (7). It should be clear to light yellow like lemonade. If it is dark (apple juice) then more fluids need to be ingested. Check the urine color before taking vitamins as large doses of B vitamins will discolor urine a brilliant fluorescent yellow. If it is tan or reddish-brown, the player should seek medical care as this may indicate blood in the urine or rhabdomyolysis.

Cold fluids are more readily consumed by hot athletes

Replace Fluids During Exercise

Since fluid intake rarely balances sweat loss it can be difficult keeping hydrated during summer practices. The American College of Sports Medicine's position (2007) on fluid replacement during exercise states that, "it is not possible to recommend a single volume of fluid replacement to suit everyone because of a variety of factors (body weight, environment, and training status) that influence fluid intake requirement during exercise. There is consensus that "drinking about 0.4-0.8 L/h of fluid during exercise is sufficient to meet fluid requirement for most people" (32). This is equivalent to 2-4 cups (16-32 ounces)/hour. To prevent nausea, it is best to break every 15 minutes and consume ½-1 cup fluid. This will also help to "train the gut" to tolerate the liquids (46). This "forced fluid consumption to maintain body weight during practice" kept leg power performance from decreasing compared to voluntary liquid intake (18). For practices longer than one hour, fluid intake should be increased to 0.6-1.0 L/h based on stomach comfort (22). Most players can tolerate 1L/h of fluids without nausea if they have normal stomach emptying rates (6).

Replace Fluids Before Practice: Pre-Hydrate, Don't Come to Practice Dry

Players should develop and be consistent with a hydration routine. Consecutive practices in the same day and sequential daily sessions lead to cumulative hypohydration. Data on high school football athletes showed that as many as 70% attended practice significantly dehydrated (18). Other research showed that players who exercised in the heat took four hours to replace half of the body fluids lost and those who were already dehydrated took three days to attain their beginning body weight (22) Each player should establish a hydration routine used both during and after practice.

With multiple practice sessions ("two-a-days"), athletes must rehydrate during each practice (15) and before the next session. Recommendations from one study suggest drinking 500 ml (two 8 ounce cups) one to two hours before practice (11). Another study suggests drinking 5-7 ml/kg (two 8 ounce cups for a 200# player) four hours pre-practice, if urine is not white or white-yellow, increase liquids to 8-10 ml/kg (3 cups for a 200# player) for the remaining two hours (7). An easy, successful rehydration strategy used in high school football players was to have each player drink a bottle (591 ml) of water or sports drink (the majority chose a sports drink) after dinner in the evening and another bottle 1.5 hours before practice the next morning (18).

Plain Water vs. Sports Drinks

Most of the studies support the use of both plain water and sports drinks as fluid replacement (11). However, a few caveats need to be heeded. Every player's sweat composition is unique. Some lose more sodium chloride than others and will need a greater salt replacement. Diet, sweat rate, level of hydration and acclimatization will vary the salt lost in sweat (47). Sodium and sweat loss increase with practices lasting longer than three hours but decreasing with acclimatization (15). Drinking water instead of a carbohydrate electrolyte drink will not provide the needed sodium and chloride ions. Armstrong found that youngsters who receive only plain water do not drink enough to correct their fluid deficit (33). Large body water losses require fluid AND electrolyte replacement to prevent hyponatremia (27).

Ingesting beverages with 20-50 mEq/L of sodium, salty snacks, or liberally salting meals will usually correct sodium deficits (7) and prevent heat cramps. Ganio found that football playerswith a previous heat cramp history had sodium losses twice the normal rate and that ingestion of additional salt ended the cramps (15). Ingesting small to moderate amounts of sodium with fluids will increase blood volume, stabilize the heart and blood pressure, increase thirst, and reduce loss of fluid through urination, thus preventing hypohydration.

A second caveat is that many factors influence the rate and amount of liquid consumed. Taste, temperature, smell, color, and texture of a drink can increase or decrease intake. Flavored drinks increase consumption by 44.5% (33) as do cooler drinks (preferred temperature is 59-70°F) (7).

A third caveat is that ingesting a small amount of carbohydrate (4-8%; >8% delays stomach emptying) with sodium increases fluid consumption (23), is beneficial to energy needs (11), and slows the onset of fatigue (47). Drinking carbohydrate-electrolyte beverages improves performance better than water alone and may increase intestinal uptake of sodium and water ,thus, adding to hydration efforts (11). Sports drinks also supply glucose to replace depleted muscle glycogen stores. Naughton found that with a 6% glucose drink time-to-fatigue was increased by 25% (23). When the drink was 6% glucose with 3% fructose added, time-to-fatigue increased to 40% (23). While potassium is an important electrolyte in rehydration due to the retention of fluid in the intracellular space (11), low potassium levels are rare since enough is typically consumed in a normal diet (47). Additionally, players have complained that some sports drinks burn their stomach and potassium is a known gastric irritant. Sports drinks with lower potassium levels may be better tolerated by the stomach in some players (Table 3). The Institute of Medicine recommends drinks that contain 20-30 mEq/L sodium chloride, 2-5 mEq/L potassium and 5-10% carbohydrate as ingredients (7) in fluid replacement beverages for heat exercise.

An informal poll of what high school football athletes drink lead to the creation of the attached drink/ingredient list (Table 3). It is interesting to note that Gatorade is a mixture of sucrose (38%), glucose (34%), fructose (28%) and maltodextrins (8%) while Powerade is mostly high fructose corn syrup (HFCS) (48). A mixture of sugars and complex glucose polymers such as maltodextrin (49) increases the oxidation and absorption of carbohydrates (50) leading to more fuel for athlete's bodies. HFCS is associated with spikes in blood sugar and obesity. Carbohydrate and sodium chloride in a beverage also raises the uptake of water through channels in the small intestine and accelerates gastric emptying (50) allowing more water to be absorbed by the body. Another study found that rehydrating with a 6% carbohydrate electrolyte drink increased the "maximum power of high school football players" when compared to drinking only water (51). With this information in mind, a mixture of water and sports drinks is a best practice in the heat of the day. This can be easily accomplished through the use of a Waterboy and a cooler of sports drinks.

Table 3. Fluid and Electrolyte Composition in Various Beverages

Name of drink[1]	Cal	Fat[2]	Na(mg)	K(mg)	K(mEq)	CHO[3]	CHO%	Pro[2]	Vit A[4]	B3	B5	B6	B12	Vit C	Vit D	Vit E	Ca	Folate	Fe	Mg+	Zinc
Apple juice 100% (Simply Apple)	120	0	5	250	6.4	30/28	12.5	0												2%	
Diet Coke	0	0	22.5	0	0	0	0	0													
Diet Pepsi	0	0	26	0	0	0	0	0													
Gatorade	25	0	110	30	0.8	7/7	2.9	0													
Gatorade A.M.	50	0	110	30	0.8	14/14	5.8	0						20%							
Gatorade (dry mix)	50	0	90	25	0.6	13/13	5.4	0													
Gatorade Endurance	50	0	200	90	2.3	14/14	5.8	0									<2%			<2%	
Gatorade Fierce	50	0	110	30	0.8	14/14	5.8	0		20%	20%	20%									
Gatorade G2	25	0	110	30	0.8	7/7	2.9	0		25%	25%	25%		10%		10%					
Gatorade Rain	50	0	110	30	0.8	14/14	5.8	0													
Gatorade Tiger	50	0	135	40	1	14/14	5.8	0													
Gatorade Tiger Focus	25	0	135	40	1	7/7	2.9	0								10%					
Gatorade X Factor	50	0	110	30	0.8	14/14	5.8	0								20%					
Life Water (Sobe)	40	0	20	0	0	16/10	6.7	0		10%	10%	10%	10%	100%		20%					
Milk Fat-free (Prairie Farms)	80	0	120	382	9.8	11/11	4.6	8	10%					2%	25%		30%				
Milk 2% (Nature's Pride)	130	5	130	366	9.4	12/12	5	8	10%					4%	25%		30%				
Orange juice 100% (Orchid Is.)	110	0	0	500	12.8	25/21	10.4	2		4%		4%	15%	140%				20%	2%		
Pedialyte (flavored)	24		212	183	4.7	6	2.5	0													
Powerade	56	0	112.5	28.5	0.7	15/15	6.3	0		11%		11%	11%								
Powerade Adv. Electrolye Ion4	50	0	100	25	0.6	14/14	5.8	0		10%		10%	10%								
Powerade Zero	0	0	55	35	0.9	0	0	0		10%		10%	10%								
Propel (made by Gatorade)	10	0	70	0	0	2/2	0.8	0		25%	25%	25%		10%		10%					
Propel Fit Water	10	0	5	0	0	2/2	0.8	0		25%	25%	25%	4%				10%				
Propel Fit (dry mix)	10	0	30	0	0	3/3	1.3	0		25%	25%	25%	25%	10%							
Root Beer (Mug)	120	0	49	0	0	43/43	18	0													
Red Bull (8.3 oz)[5]	110	0	200	0	0	28/28	11.7	<1		100%	50%	250%	80%								
Smart Water (Glaceau)	0	0	2.5	2.5	0.06	0	0	0												4%	
Snapple Antioxidant Water	50	0	0	0	0	13/13	5.4	0	10%	20%	20%	20%	20%			10%	2%			2%	2%
Vitamin Water (Glaceau)[6]	50	0	0	0	0	13/13	5.4	0													

1. All values are based on a measurement of eight (8) fluid ounces and taken from label on bottle or can.
2. Fat and protein are measured in grams.
3. Carbohydrates with two values are the total carbohydrates in grams over the sugars in grams.
4. Percent daily values (DV) of all vitamins and minerals are based on a 2000 calorie diet.
5. Contains taurine, glucuronolactone, and caffeine but no amounts listed.
6. Glaceau Vitamin Water has varied amounts of added vitamins and stimulants depending upon flavor. Included only basic caloric and electrolye content that is the same for all flavors.

Optimal drink during exercise

Optimal drink after exercise

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Replace Fluids After Exercise

Recommendations advise replacing 25-50% more fluids than sweat lost to cover urinary, respiratory, and sweating losses (27). A standard to use is to replace 130-150% of sweat lost (change in body weight) during exercise minus the liquids consumed during practice (26, 27, 52). For example, if a player loses 2 L of fluid in sweat/body weight and drinks nothing during practice, then he should drink 2.6-3 L to replace the deficit. Oral fluid replacement is a practical method for improving performance (22) and results in greater cardiovascular stability, lower perceived exertion, reduced body temperature, and decreased thirst than intravenous fluid resuscitation (15). This show that it is obviously better to prevent dehydration than try to treat it in the hospital. Additionally, electrolytes and carbohydrates can be obtained through the ingestion of bars, gels, candies, and other solid preparations, not just beverages.

Replace every 2.2 pounds of weight lost from practice with 1.3-1.5 liters of fluid, preferably a sports drink

Eat Properly

Regular ingestion of meals will both increase intake and retention of liquids (7) and supply metabolic fuel needs after and prior to the next practice. Nutritional goals before exercise are to be well-fueled; after exercise they are to boost glycogen recovery in the muscles and replace fluids (52). Knowing a player's food intake pre-practice (Figure 4) and educating them on the five food groups will serve to increase performance. For a high school male athlete, a balanced diet equals 50-60% carbohydrates, 20-30% fats, and 12-15% proteins with a 3000-6000 calories/day intake (26).

Teenagers are notoriously poor followers of good nutrition and often eat "fast food" be it from actual fast food chains or the freezer at home. A player who is hungry, post-exercise, generally wants a quick fix and will reach for the most easily obtained food source. A study by Hartman showed that drinking 500 ml (two 8 ounce cups) of fat-free milk immediately after exercise and one hour post-exercise resulted in greater gains in muscle fiber mass and a reduction of fat mass when compared to ingesting a soy protein "isonitrogenous, isoenergetic carbohydrate" matched beverage (53). Low-fat milk was also found to be better than sports drinks in post-exercise rehydration since it was absorbed more slowly into the bloodstream and didn't cause fluctuations in the blood's osmolality, thus, it promoted a reduction in urine output (53) and quicker rehydration. Milk is also full of electrolytes and protein (Table 3). In summary, fat-free milk increases muscle mass, decreases fat mass, increases hydration, and is a quick and easy teen food.

Coaches, Trainers, and Parents

Educate Everyone

Team members, coaches, trainers and parents should all be educated regarding the recognition, prevention, and treatment of heat illness symptoms; proper hydration techniques before, during and after practice; good nutritional intake at meals; and the influence of heat exercise on medical conditions. All players, coaches and parents should be aware of players with existing medical conditions, what medications they use, where these are stored, and how to treat exacerbations. Parents should assure that players eat and drink adequately before and after practice. Each player should have a buddy. Establishing a mandatory pre-season parent-player meeting where these issues can be presented and discussed should be implemented.

Have an Emergency Plan

All football teams should have an emergency plan in place with coaches, trainers and players trained how to respond. Specific persons should be assigned to each action plan task. Tasks include those who will contact EMS, bring the paramedics to the field, take care of the downed player, and supervise the emergency (38). For heat illness due to over-exertion, equipment (cooled liquid drinks, iced water in coolers and/or

"kiddie" pools, wet towels, fans, shaded area or tent) should be readily accessible on the field. The gold standard of caring for heat illness is to "cool first, transport second," emphasizing the importance of rapidly reducing the core temperature until it reaches at least 102°F if not lower (54).

Conclusions

Heat cramps, heat exhaustion, and heat stroke are preventable by following a few simple measures to avoid dehydration. High school football players are old enough to take some responsibility for their health, but will need oversight by coaches, trainers and parents. Players listed those who had the greatest influence on hydration practices as coaches (65%), sports dieticians (30%), and physicians (25%) with the coach additionally listed as the best information source on supplement use (35). Knowledge of risk factors and use of suggestions for decreasing risk are important for all players and coaches who are concerned with preventing heat illness.

Appendix A. NOAA's National Weather Service. Table 1. Heat Index and Heat Stress Chart. Available at: http://www.crh.noaa.gov/jkl/?n=heat_index_calculator [Accessed 04-01-09]

Appendix B. National Oceanic & Atmospheric Administration (NOAA) Quality controlled local climatological data: Spirit of St. Louis Airport (August 2006, 2007, 2008, August 15 2007 & 2008). http://cdo.ncdc.noaa.gov/qclcd/QCLCD. Accessed 04-09-09 [Accessed 04-10-09]

Appendix C. Sample Player Health Records from St. Louis area school districts

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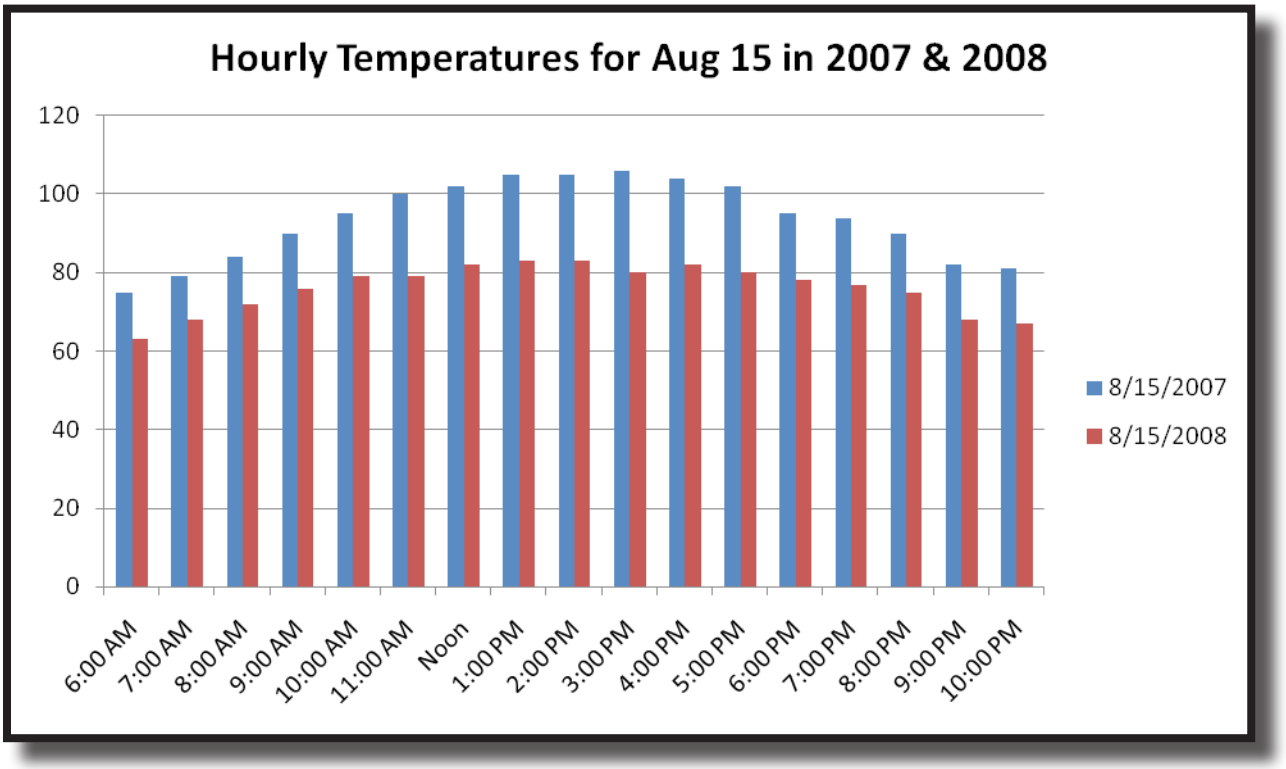
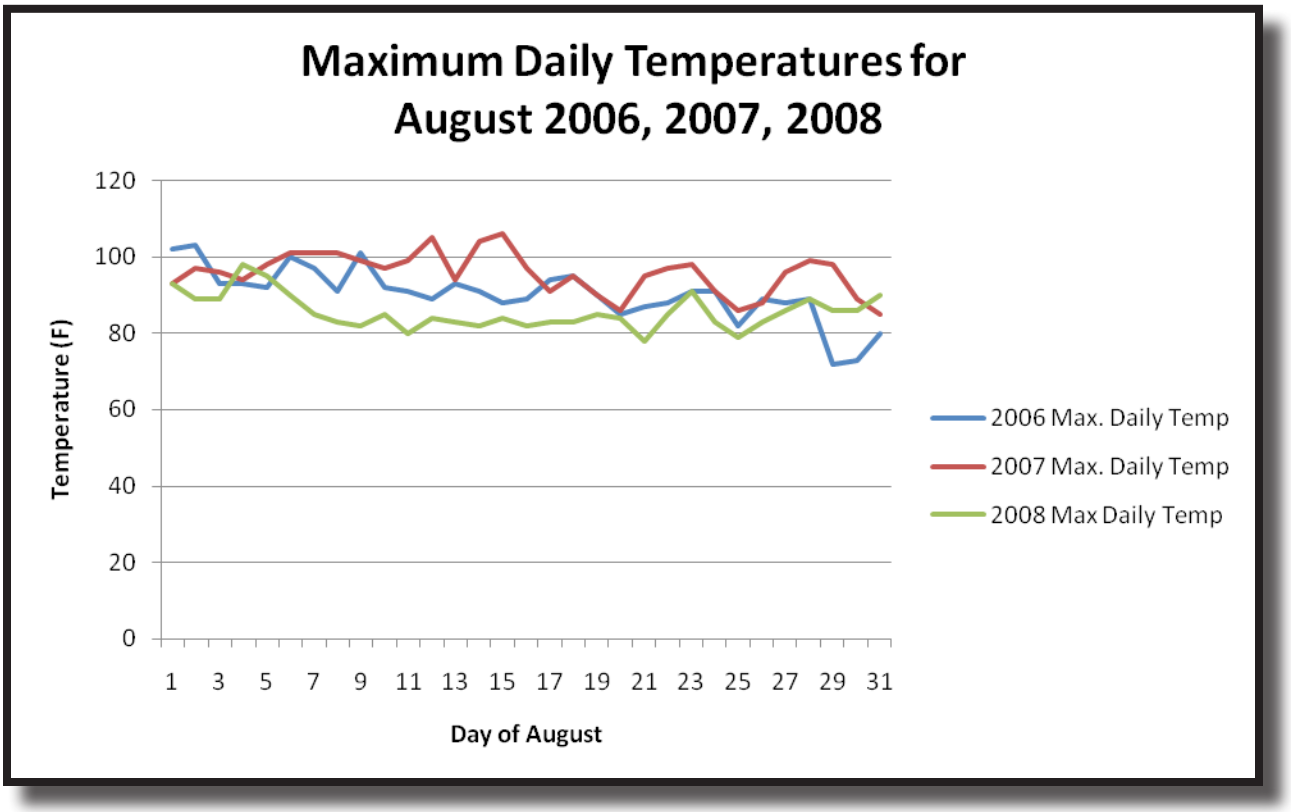
APPENDIX A. NOAA National Weather Service. Table 1. Heat Index and Heat Stress Chart. Available at: http://www.crh.noaa.gov/jkl/?n=heat_index_calculator [Accessed 04-01-09]

HEAT INDEX °F (°C)													
	RELATIVE HUMIDITY (%)												
Temp.	40	45	50	55	60	65	70	75	80	85	90	95	100
110 (47)	136 (58)												
108 (43)	130 (54)	137 (58)											
106 (41)	124 (51)	130 (54)	137 (58)										
104 (40)	119 (48)	124 (51)	131 (55)	137 (58)									
102 (39)	114 (46)	119 (48)	124 (51)	130 (54)	137 (58)								
100 (38)	109 (43)	114 (46)	118 (48)	124 (51)	129 (54)	136 (58)							
98 (37)	105 (41)	109 (43)	113 (45)	117 (47)	123 (51)	128 (53)	134 (57)						
96 (36)	101 (38)	104 (40)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	132 (56)					
94 (34)	97 (36)	100 (38)	103 (39)	106 (41)	110 (43)	114 (46)	119 (48)	124 (51)	129 (54)	135 (57)			
92 (33)	94 (34)	96 (36)	99 (37)	101 (38)	105 (41)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	131 (55)		
90 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	103 (39)	106 (41)	109 (43)	113 (45)	117 (47)	122 (50)	127 (53)	132 (56)
88 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	98 (37)	100 (38)	103 (39)	106 (41)	110 (43)	113 (45)	117 (47)	121 (49)
86 (30)	85 (29)	87 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	102 (39)	105 (41)	108 (42)	112 (44)
84 (29)	83 (28)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	92 (33)	94 (34)	96 (36)	98 (37)	100 (38)	103 (39)
82 (28)	81 (27)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	91 (33)	93 (34)	95 (35)
80 (27)	80 (27)	80 (27)	81 (27)	81 (27)	82 (28)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	86 (30)	87 (31)

Category	Heat Index	Possible heat disorders for people in high risk groups
Extreme Danger	130°F or higher (54°C or higher)	Heat stroke or sunstroke likely.
Danger	105 - 129°F (41 - 54°C)	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	90 - 105°F (32 - 41°C)	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	80 - 90°F (27 - 32°C)	Fatigue possible with prolonged exposure and/or physical activity.



Graphs created from data taken from the National Oceanic & Atmospheric Administration (NOAA) quality controlled local climatological data from the Spirit of St. Louis, MO Airport (August 2006, 2007, 2008 monthly and August 15, 2007 & August 15, 2008 hourly). http://cdo.ncdc.noaa.gov/qclcd/QCLCD [Accessed 04-10-09].



LAFAYETTE HIGH SCHOOL
ACCIDENT AND HOSPITALIZATION VERIFICATION

The Rockwood School District does not furnish accident and hospitalization insurance for those students participating in extracurricular activities. The Missouri State High School Activities Association requires that all students participating in activities must acknowledge through the signature of their parent or legal guardian that their parent or guardian have provided basic insurance coverage on them before they will be allowed to practice or participate in interscholastic activities.

My son/daughter _____ is presently insured by _____, an accident and hospitalization policy, which includes coverage for injuries while he/she is actively participating in supervised interscholastic or games.

ACTIVITY GUIDELINES CONTRACT

Representing Lafayette in interscholastic activities is entirely voluntary on my part and is made with the understanding of the eligibility standards.

I am aware that trying out, practicing, or any other form of participation in any activity can be dangerous and involve risk of injury. I understand that the dangers and risks of playing or practicing could lead to the possibility of minor to severe injury and I assume that risk.

Because of the dangers of participating in activities, I recognize the importance of listening to and following all of the coach's/sponsor's instructions and warnings, and the importance of reading and adhering to all written instructions and written warnings regarding playing techniques, training methods, and rules of the activity.

I understand and promise to obey all instructions and warnings, verbal or written, in regard to my participation in activities. I also agree to waive all claims of any nature and to release the school district, school, teachers, board members, employees, athletic staff, (athletic director, coaches, athletic trainer), physicians, and other practitioners from any and all liability for any injuries, actions, causes of action, debts, claims, or demands of every kind and nature whatsoever which may result from or in connection with my participation in any type of school activity.

I also have read and understand that the result of not meeting the "Citizenship Standards" found in the Lafayette student handbook could mean not being allowed to participate either temporarily or permanently in the activities program.

_____ _____

Student's Name PRINTED Student's Signature

As a parent/guardian, I understand the above statements that my student has agreed to uphold. I also understand that the school may not provide transportation to all events, and permit/do not permit (Circle One) my child to drive his/her vehicle in such a case.

_____ _____

Parent's Signature Date

PLEASE RETURN TO THE COACH OR THE SPONSOR AFTER SIGNING

ROCKWOOD SCHOOL DISTRICT PHYSICAL EXAMINATION FORM

FOR

KINDERGARTEN • NEW STUDENTS • GRADE 6 • HIGH SCHOOL SPORTS

PLEASE RETURN COMPLETED HEALTH EXAMINATION FORM TO THE SCHOOL NURSE.
ANY QUESTIONS REGARDING COMPLETION OF THIS FORM MAY BE DIRECTED TO THE SCHOOL NURSE.

STUDENT NAME: _____ DATE OF BIRTH: _____ GRADE: _____

TO BE COMPLETED BY EXAMINER
DATE OF EXAM: _____

IMMUNIZATIONS (give month/day/year or attach record)

DTP _____ _____ _____ _____ _____

DTaP/Td _____ Hep B _____ _____ _____

Polio _____ _____ _____ _____ _____

MMR _____ _____ Hep A _____ _____

Varicella _____ _____ or Date of Illness _____

HIB _____ _____ _____ _____

PPD + /- _____ Menactra _____

HPV _____ _____ _____

Other _____

HISTORY

Asthma: No_____ Yes_____

ADHD: No_____ Yes_____

Chronic Condition/Major Surgeries: (list, give date) _____

_____

Allergies (list): _____

Medications (list): _____

ORTHOPEDIC HISTORY (for sports participation)

Previous Injury Date, Explain: _____

_____

_____

PHYSICAL

Height: _____ Weight: _____ B/P: ____ / ____ Pulse: _____

Eyes: R – 20/ _____, L – 20/ _____ Hearing: _____

Scoliosis screening _____

Review of Systems: WNL

If not, please explain: _____

_____

ORTHOPEDIC EXAM (for PE/sports participation)

Back/Neck/Shoulders/Extremities: WNL

If not, please explain: _____

_____

Recommendation for PE/Sports: Full / Limited / None

Clearance withheld until: _____

If limitations, please explain: _____

_____

SIGNATURE of EXAMINER: _____

Name (please print): _____

Address: _____

_____

Phone: _____

Special Seating Recommendations: _____

Medical Treatment Needed at School: _____

Other Health Recommendations: _____

FOR HIGH SCHOOL SPORTS PARTICIPATION ONLY - Parent's or Guardian's permission: I hereby give my consent for the student to represent his/her school in interscholastic activities, except those stated on the form by the examiner; I also give my consent for him/her to accompany the team as a member of its out-of-town trips and will not hold the school responsible in case of accident or injury. I also give consent and authorize the school to obtain, through a physician of its choice, such medical care as is necessary for the welfare of the student, if he/she is injured in the course of school activities.

Signature of Parent _____ Date _____

PARKWAY SCHOOL DISTRICT

REPORT OF PHYSICAL EXAMINATION and/or MSHSSA PARTICIPATION CERTIFICATE

(Grades 9 – 12)

Physical examinations are recommended upon entrance into school and at the beginning of the 3rd, 6th, and 9th grades. The Missouri State High School Activities Association requires a yearly physical examination prior to participation in inter-scholastic athletics in grades 9 through 12.

So much of your student's success and happiness in school and in life are dependent upon his/her physical and mental health that we are confident this information is vital in providing the best school life for your student. We shall appreciate your cooperation and help in this important matter.

Robert Malito, Ph.D.
Superintendent

School _____ Current Grade _____

Student's Name _____
(last) (first) (middle)

Date of Birth _____ Gender: O Male O Female

Father/Guardian _____

Mother/Guardian _____

Physician _____ Phone _____

Dentist _____ Phone _____

Orthodontist _____ Phone _____

1. HISTORY OF IMMUNIZATION

REQUIRED BY MISSOURI STATE LAW

Please attach a **COPY** of student's permanent immunization record from your health care provider, Health Department, or previous school. Month, day, and year must be provided for all immunizations received, including infant series.

PLEASE RETURN THIS FORM TO THE SCHOOL NURSE

2. HISTORY OF ILLNESS

Enter the year(s) in which your student had the following:

ANEMIA	_____	MUMPS	_____
ASTHMA	_____	PNEUMONIA	_____
CHICKEN POX	_____	RHEUMATIC FEVER	_____
DIABETES	_____	RUBELLA	_____
HEPATITIS [JAUNDICE] (Specify Type - A, B, C, D or E)	_____	SCARLET FEVER	_____
		SEIZURE DISORDER	_____
MEASLES	_____	STREP THROAT	_____
MENINGITIS	_____	TUBERCULOSIS	_____

3. HEALTH INFORMATION

Please list any allergies, injuries, operations, serious illnesses, heart conditions, vision problems, hearing loss, and any other health information you feel would be helpful:

_____

_____

_____

Dental (dental bridges, false teeth, etc.)

_____

Is your student on medication at home or school? O Yes O No

Specify name of medication(s), dosage, reason prescribed:

_____

_____

Is your student currently under medical care? O Yes O No

Specify:

_____

_____

MSHSAA PARTICIPATION CERTIFICATE - Parent/Student
(Missouri State High School Activities Association)

Section 1. **Athlete's application and personal information**

This application to represent my school in interscholastic athletics is entirely voluntary on my part and is made with the understanding that I have studied and understand the eligibility standards that I must meet to represent my school and that I have not violated any of them. I also understand that if I do not meet the citizenship standard set by the school or if I am ejected from an interscholastic contest because of any unsportsmanlike act, it could result in me not being allowed to participate in the next contest or suspension from the team either temporarily or permanently.

I have completed and/or verified that part of this certificate, which requires me to list all previous injuries or additional conditions that are known to me, which may affect my performance in so representing my school, and I verify that it is correct and complete.

_____ Date_____

Signature of Student

Section 2. **Parent permission and authorization for treatment**

We hereby give our consent for the above student to represent his/her school in interscholastic athletics. We also give our consent for him/her to accompany the team on trips and will not hold the school responsible in case of accident or injury whether it be en route to or from another school or during practice or an interscholastic contest, and we hereby agree to hold the school district of which this school is a part, its employees, agents, representatives, coaches, and volunteers harmless from any and all liability, actions, causes of action, debts, claims, or demands of every kind and nature whatsoever which may arise by or in connection with participation by my student/ward in any activities related to the interscholastic program of his/her school.

If we cannot be reached and in the event of an emergency, we also give consent for the school to obtain through a physician or hospital of its choice such medical care as is reasonably necessary for the welfare of the student, if he/she is injured in the course of school athletic activities. We understand that the school may not provide transportation to all events, and **permit / do not permit** (*circle one*) my student to drive his/her vehicle in such a case.

We further state that we have completed that part of this certificate, which requires us to list all previous injuries, or additional conditions that are known to us which may affect this athlete's performance or treatment, and we certify that it is correct and complete.

The MSHSSA By-Laws provide that a student shall not be permitted to practice or compete for a school unit until it has verification that he/she has basic athletic insurance coverage. Our son/daughter is covered by basic accident insurance for the current school year with

_____

(Name of Insurance Company) (Policy No.)

Signatures of Parents/Guardians (all parents or guardians must sign.)

_____ Date_____

_____ Date_____

NOTE: PHYSICIAN TO COMPLETE

4. PHYSICAL FINDINGS

Height	_____	Weight	_____
Pulse	_____	Blood Pressure	_____
Nutrition	_____	Skin	_____
Scalp	_____	Teeth	_____
Gums	_____	Nose	_____
Throat	_____	Ears	_____
Eyes	_____	Heart	_____
Lymph Glands	_____	Lungs	_____
Abdomen	_____	Orthopedic	_____
Scoliosis	_____	Genitalia	_____
Neuroligical	_____	Urine	_____
Hernia	_____		

Significant Concerns: _____

_____

Do immunizations comply with Missouri State Law? O Yes O No

Can student carry a full program of schoolwork? O Yes O No

Should physical activity at school be restricted? O Yes O No

If YES, please state to what extent and for how long. _____

_____

_____

FOR INTERSCHOLASTIC ATHLETICS ONLY

Based on the limited examination above, this student _____ may _____may not participate in supervised athletics.

_____ _____

Signature of Physician Date of Examination

Medical History

Allergies _____ Rheumatic Fever _____ Mumps _____

Measles _____ Whooping Cough _____ Scarlet Fever _____

Polio _____ German Measles _____ Chicken Pox _____

Other _____

Recommendations:

Can the student carry a full school program? Yes ___ No ___

Does the student have any irremediable defects? Yes ___ No ___

Should physical activity be restricted? Yes ___ No ___

Is special seating recommended? Yes ___ No ___

Other _____

Remarks _____

_____ _____

Signature of Examining Physician Date of Examination

AUTHORIZATION FOR MEDICATION TO BE TAKEN DURING SCHOOL

Medication _____

Reason _____

Route, time, and dose to be given at school _____

Special Instructions/ Restrictions/ Important Side Effects:

_____

Signature of Physician _____ Date _____

Printed Name of Physician _____ Phone _____

Parent/Guardian Signature _____

PARENT/GUARDIAN OR RESPONSIBLE ADULT MUST BRING ALL MEDICATIONS TO THE SCHOOL NURSE.

HAZELWOOD SCHOOL DISTRICT HEALTH SERVICES

Name of Student _____

Address _____ Phone _____

School _____ Grade _____

Birth date _____

To the Parent:
Every child attending the Hazelwood School District should have a physical examination at the beginning of the school year in Kindergarten, 4, 7, 10. Students new to the school system should have a complete physical examination regardless of grade level.

This form is furnished for the convenience of your child's physician. Please have the physician complete this form at the time of the examination and bring it or mail it directly to the school.

It is our belief that this information enables the home and school to cooperate more effectively in preventing defects or caring for them after they have developed. So much of your child's success and happiness in school and in life is dependent upon his/her physical and mental health that we are confident that this information is vital in providing the best school life for your child. We shall appreciate your cooperation in this important matter.

Sincerely,
The School Nurse

April, 2009

For the Physician:
The School Health Services is particularly interested in any deviation from the normal and whether there should be any restrictions on this student's school activities. It is through this means of communication that the schools can best serve the needs of the individual student. You are urged to call the School Nurse about any unusual situation in order that the school may better plan the student's school program and be of optimal service to each student.

Chris Wright
Superintendent

IMMUNIZATIONS AND TEST: (Mo., Day, & Year) * Required by law
****Ten Years after DPT Series**
***** Required by law for children Entering Kg-4th**

DPT	*	*	*	*		
TD	**					
IPV/ OPV	*	*	*	*		
MMR	*	*				
Hep B	*	*	*			
C. Pox	***					
HIB						
Hep A						
PPD						

***If the child has had the Chicken Pox disease, a statement signed by The parent/physician is required indicating the month and year the Child had the disease**

PHYSICAL FINDINGS

Height _____ Weight _____

Nutrition _____

Skin and Hair _____

Teeth and Gums _____

Nose _____

Throat _____

Tonsils Enlarged_____ Removed _____

Ear and Ear Drums _____

Eyes and Eyelids _____

Vision OD_____ OS _____ Both_____
(for Kindergarten and new First grade students please complete Missouri Eye Exam Form)
Heart _____ BP _____

Lungs _____

Lymph Glands _____

Hernia _____

Orthopedic _____

Scoliosis Screening _____

Urinalysis SpG _____React_____ Alb _____ Sug _____