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Correlation Established between Body Fat Percentages and Core Temperature Changes in NCAA Division I Athletes

Jeffrey B. Roberts, Samuel B. Boggess, David J. Berkoff, Blake R. Boggess*

Duke University School of Medicine, Duke Sports Medicine Team Physician, North Carolina, US.

*Correspondence:
Blake Boggess, DO, FAOASM, FAMSSM, Professor, Duke University School of Medicine, Duke Sports Medicine Team Physician, North Carolina, US.

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ABSTRACT

Many factors affect the body's ability to maintain a homeostatic core temperature. A body's inability to maintain homeostatic core temperature can lead to heat illness. Football players have several risk factors for heat illness as they compete in harsh conditions. The goal of this study was to determine if there is a correlation between body fat percentages and core temperature changes in NCAA Division I college football players. Results displayed a linear correlation between increased body fat and elevated core temperatures once the environment's temperature hit a threshold of 92 degrees. In addition to this correlation, the study reiterates the importance of monitoring weather conditions as a risk factor for heat illness.

Keywords
Body fat, Illness, Stroke.

Introduction

There are many factors that affect the body's ability to maintain a homeostatic core temperature. These variables can be both intrinsic (i.e. age, pre-existing medical conditions, medications) and extrinsic (i.e. ambient temperature, humidity, wind). When the body's ability to regulate core, temperature is overwhelmed by these variables, heat illness can result. The spectrum of heat illness ranges from minor heat cramps to severe, often fatal heat strokes. Heat illness is common in both the community and athletics with an estimated 240 deaths due to heat strokes annually in the U.S. and is the third leading cause of death in high school athletes in the U.S. behind cervical spine injuries and cardiac conditions [1,2]. Education and prevention strategies are essential in reducing the incidence of heat illness, however, when heat illness does occur, early recognition and treatment is necessary to prevent poor outcomes.

Heat illness can develop from environmental exposure which usually affects the very young, elderly or chronically ill, or from exertion which usually affects the athlete or younger, active individuals [2]. Evaporation is the body's most effective method of cooling under most circumstances, dissipating up to 600 kcal per hour in optimal conditions. Thermoregulation is controlled by the hypothalamus which triggers peripheral vasoconstriction (radiant heat loss), sweating (evaporative heat loss), and cardiac changes [1].

Heat cramps are muscle spasms that usually affect the arms, legs, or abdomen. It is often seen in athletes who have excessive heat exposure and are mildly dehydrated. The pathophysiology of heat cramps is poorly understood but could be due to sodium depletion. Repeated exposure to hot, humid environments over several days increases the risk of heat cramps. The untrained or poorly acclimatized athlete is also at increased risk due to higher sodium concentration per liter of sweat lost as well as a decreased ability to produce sweat than well conditioned athletes (trained athlete – 3-4L of fluid/hr with 5 meq of salt per liter; poorly conditioned athlete 1-2 L of fluid per hour with 65 meq of sodium per liter) [3]. Heat cramps are a mild form of heat illness but could become more severe if not recognized and treated appropriately. The athlete should be moved to a cool, shaded area and given oral or parental fluids as well as sodium replacement. Stretching the involved muscle group can relieve some discomfort [1-3].

Heat exhaustion is a more severe form of heat illness that results from excessive water and sodium loss which can impair the body's ability to regulate core temperature. Athletes often have headaches, myalgias, nausea, vomiting, hypotension, tachycardia, and cutaneous flushing [1-3]. Treatment involves moving the person to a cool shaded area, rehydration, and sodium replacement.

This most dangerous form of heat illness is heat stroke which occurs when the body has lost the ability to thermoregulate. Heat stroke is classified into two types, classical and exertional. Classical heat stoke is usually in the very young or elderly who have had over exposure to harsh environmental conditions. Exertional heat stoke can occur in temperate and extreme weather and is often found in athletes whose bodies are unable to regulate core temperature while undergoing physical activity. Many of the signs and symptoms overlap with heat exhaustion but those with heat stroke will have altered mental status (confusion, ataxia, seizures) and a core temperature of greater than 40 degrees Celsius [4]. Early recognition and treatment are essential as mortality can approach 10 percent [1].

The person should be moved to a cool, shaded area, airway, breathing, and circulation monitored, and cooling methods started immediately. Rapid cooling is essential in the treatment of heat stroke and begins with removal of his or her cloths. Immersion cooling involves placing the person in an ice bath [1-6]. There is debate about using this technique as it can cause peripheral vasoconstriction which will decrease the cooling effect and can lead to shivering which will result in generation of heat from muscle activity. In the field it is usually easier to use a combination of convective and evaporative methods of cooling. This involves spraying cool water on the individual while fanning them. Many centers use body cooling units which spray water at 15 degrees Celsius and use warm air flow to maintain skin temperature at 32-33 degrees Celsius [1-3,4,5]. The warm air prevents peripheral vasoconstriction and shivering while cooling. Ice bags may also be placed in the axilla, neck, and groin to add conductive heat loss.

There have been no head-to-head trials comparing these techniques, so it is difficult to say which is superior [1-3,4,5]. Intravenous access should be obtained, and the patient should be transported to a medical facility as soon as possible. Rectal temperature should be taken frequently to determine core body temperature and cooling stopped when rectal temperature has reached 38 degrees Celsius [1-3,4,5]. Other forms of cooling such as gastric and bladder ice water lavage and the use of dantrolene have not proven to affect outcomes and are only adjunctive therapy at best.

Many factors must be considered as risks for development of heat illness. Age plays a significant role as the very young, elderly, and chronically ill often have altered hypothalamic responses and sometimes limited ability to rehydrate without assistance [1]. Certain medications and substances such as alcohol, amphetamines, cocaine, beta blockers, and diuretics increase the risk of heat illness [1,3]. Extremes of body weight either anorexia or obesity places a person more at risk. Underlying medical conditions such as cardiac disease, hypertension, diabetes, and thyroid disorders can affect thermal regulation. The environmental conditions including temperature, humidity, and wind condition dramatically affect the body's ability to regulate core temperature [1,3]. Clothing also plays a role in heat illness which is especially true in certain sports such as football. It is also important to let athletes acclimatize over a 14-day period to allow the body to adjust to extreme environments. These risk factors must be considered when dealing with a patient suspected of having a heat illness, as early recognition and treatment is essential.

Football players have several risk factors for heat illness as they often compete in harsh conditions that involve high temperatures and humidity. The required equipment is also a confounding factor as it limits natural heat loss from the body. Prevention is the key element in dealing with heat illness. Recognition of risk factors remains a critical roll in prevention and is a focus of this study. The goal of this study was to determine if there is an association between core temperature changes and body fat percentage in NCAA football players. The hypothesis is differences in core temperature changes during exercise are directly associated to body fat percentages in NCAA Division I college football players.

Methods

This experiment was a prospective, cohort study of division I football players (N=20) that was conducted at Wallace Wade Stadium Durham, NC. The athletes were randomly selected from the football roster and were consented prior to participation. Players had previously had their percent body fat tested using the Bod Pod©, which utilizes air displacement and calculation of lung volumes to calculate percent body fat. Players were excluded if they could not swallow the core temperature capsule. The participants swallowed a core temp capsule 1 hour prior to the morning practice. Full football uniforms were worn, and no adjustments were made to the practice regimen. Fluid intake was not monitored or controlled. Testing occurred twice on the same day during morning and afternoon practices. The testing format involved measuring the athletes core temperature before practice, at 30-minute intervals during practice and 30 minutes after practice.

Statistical Methods

Pearsons correlations were calculated comparing morning weight loss and percent body fat, percent body fat and core temperature change during the morning and afternoon practices, and the morning weight and the morning weight loss. Significance was set at $P \leq 0.05$.

Results

Temperature and humidity were taken during the morning and evening practice. The average field temperature was 87ºF and 99ºF respectively and the relative humidity was 73% and 50% respectively for the two practices. Correlations between body fat percent and core temperature changes for the morning practice (n=20) were r=0.028. There were five values that appeared erroneous but repeat correlations with these values removed were again insignificant (0.103). For the afternoon practice, the correlation between body fat percentage and core temperature changes was r=0.458 with a p-value < 0.05.

Table 1

	Practice #1	Practice #2
	9:00am	4:30pm
Average ambient temp (deg. F)	81.0	89.1
Average field temp (deg. F)	87.0	99.7
Average Relative Humidity	72.1	50.4

Table 2

		Practice #1					Practice #2						
Player	BF%	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	Temp 1	Temp 2	Temp 3	Temp 4	Temp 5	BF%	Wt Loss
1	9.9	99.3	99.8	100.3	98.3	86.8*	99	99.3	100	100.8	101.1	9.9	0
2	11.8	98.5	99.1	99.7	100.2	100.6	99.3	99.9	100.8	100.5	101.4	11.8	5
3	21.5	98.4	99.1	97	97.5	94*	98.3	99.5	99.9	101.3	101.2	21.5	6.9
4	8.5	97.9	99.8	100	100.4	100.7	99.5	100.1	99.9	98.8	100.3	8.5	3
5	16.4	97.4	98.9	100.2	100.3	100.4						16.4	3.5
6	23.2	99.6	99.8	100.1	100.7	101.6	99	99.5	100.4	101.2	100.8	23.2	0
7	8.8	98.6	99.5	99.3	100.1	100.1	99	99.4	100.5	101.1	99.8	8.8	2.1
8	18.1	97.8	98.8	99.5	99.5	94*	98.9	99.5	100.6	100.3	99.1	18.1	4
9	22.9	95.9	95.8	97.8	100.2	100.8	99.8	100.2	100.7	101.3	100.9	22.9	7
10	28.9	98	100.1	100.1	100.2	100.5	99.2	100.1	100.8	101.4	101.4	28.9	2
11	18.6	100.8	101.4	101.8	102	101.6	99.4	100.6	101.8	102.4	102.3	18.6	4
12	21	98.4	98.6	99	99.2	99	98.8	99.2	100.4	101.2	101.2	21	0
13	24.9	98.1	99.1	99.4	89.1*	89.5*	99	100	101.4	101.7	101.6	24.9	8.2
14	18.3	86.7	98.7	99.6	100	99.5	99.1	99.6	98.1	99.2	100.1	18.3	2.3
15	6.7	97.6	99.6	100.6	100.5	100.9	99	99.4	100.1	100.1	100.2	6.7	2
16	9.9	98.9	99.4	97.3	100.4	100.1	97.4	99.4	98.2	99.4	97.3	9.9	0
17	21	98.7	100.4	100.9	101.1	101.2	99.6	100.4	100.9	101.2	101.2	21	4
18	18.1	97.8	97.2	99.5	101.3	100.4	98.9	99.4	100.6	98.5	100	18.1	2.8
19	23	98.1	99.1	100	100.3	100.1	98.9	98.9	100.9	101.1	101.4	23	6
20	13.1	96.2	97.8	99.4	95	96.4	99.4	99.2	100.5	101.1	101.1	13.1	5

*Marked are the five values that appeared erroneous.

Table 3

Pearson's Correlations r values	Body Fat %	Morning Weight Lost and % Body Fat r=.349. n.s.
Morning Weight Loss	0.349	%Body Fat and Core Temp change, AM (n=20) = .028, n.s.
Core Temp Change AM practice (all subjects n=20)	0.028	%Body Fat and Core Temp Change, AM (n=16) = .103, n.s.
Core Temp Change (without erroneous values n=16)	0.103	
Core Temp Change PM practice (all subjects n=20)	0.458	%Body Fat and Core Temp Change, PM (n=20) = .458, p<.05
		AM Weight and AM Weight Lost .349, n.s.

Discussion

In consulting the data, a linear correlation appears between increased percent body fat and elevation in core temperature when the temperature exceeds 92 degrees. Therefore, it can be interpreted through this prospective, cohort study of division I football players (N=20) that percent body fat is a factor in core temperature changes when the heat index is 92 degrees or higher. The critical temperature of 92 degrees was selected as this was the temperature during the afternoon practice where the percent body fat demonstrated an effect on the core temperature. During the morning practice the temperature ranged from 81-87 dgr and the afternoon practice ranged from 89.1-99.7. The core temperature did not show any significant variance when compare to percent body fat until the ambient temperature was 92 degrees and higher.

There are many other factors that affect core temperature that this study did not address or control for. Fluid intake was not monitored or rationed in any manner. With dehydration also being a component of heat illness, it would be important to ensure that the athletes were well hydrated prior to and during practice. Although hydration was not monitored, all athletes participated in water breaks during practice and no one demonstrated symptoms of heat illness during or after practice. Cold fluids could also lead to erroneously low values when testing core temperatures if the Core Temp ® capsule was still located in the stomach. This was likely what occurred with the extraordinary low values seen on the five values that were dismissed. The intensity of exercise will also affect core temperature, however, the duration and level of exertion during practice not controlled. Athletes participated in football practice that was not altered for the study. The cohort of athletes was composed of players from different positions, which resulted in different work out routines during practice. The small sample size also weakened the statistical power of the analysis. A follow-up study with a larger cohort that controlled for fluid intake and intensity in exercise would be optimal.

Conclusion

Heat exhaustion and heat stroke remain significant causes of lost time and injury in athletes, particularly football players, in the hot climates and during two-a-day practices. Additional tools, such as determination of percent body fat, to identify those players most at risk can be of great value in preventing future illness and death. This also reiterates the importance of monitoring weather conditions especially during hot, humid summer months, to determine the safety of participation in certain climates.

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