

Wet Bulb Globe Temperature Monitoring

A WBGT device is a measurement tool that uses ambient temperature, relative humidity, wind, and solar radiation from the sun to get a measure that can be used to monitor environmental conditions during exercise. Establishing WBGT guidelines that dictate modifications in activity (work:rest ratios, hydration breaks, equipment worn, length of practice) at given WBGT temperatures play a huge factor in helping to prevent EHS.

As environmental temperature and humidity increase, there is an increase in the heat stress that is placed on the exercising individual. Exercise in the heat causes athletes to rely on evaporation of sweat from the skin as the primary method of dissipating heat that is produced by the working muscles. As humidity increases, the ability to dissipate heat through evaporation is further hindered, thus causing the body to have an increased body temperature, which increases the risk of EHS.

When examining deaths that have occurred from EHS during American football, most of the deaths (~65%) have occurred during the month of August in the eastern quadrant of the US. In addition, over half of the reported deaths occurred during morning practices when humidity levels were high. These results show a direct correlation between increased temperature and humidity levels and risk of mortality as a result of EHS.

History

The use of WBGT as an environmental monitoring measure during exercise in the heat was invented in the early 1950's in response to the number of heat casualties occurring in the United States armed services that occurred during the 1940's and 1950's. For example, from 1942-1944, 198 soldiers died due to heat illness during military training.

In response to the large number of heat illness cases, the military began to make modifications to training sessions when environmental conditions reached extreme levels. Initially, temperature and humidity levels were used when making training modifications and were later changed to using WBGT as a preventive measure to protect against heat illness. After implementing WBGT policies in the military, there was a drastic reduction in heat illnesses during basic training.

Components

As mention above, WBGT utilizes ambient temperature, relative humidity, wind, and solar radiation from the sun to get a composite value that can be used when monitoring environmental conditions during exercise in the heat. The equation below uses all of these components to calculate WBGT.

WBGT Guidelines

As it was mentioned above, WBGT can be used to establish guidelines for activity modifications during physical activity in the heat. The United States Military uses WBGT to modify basic training during extreme conditions. The chart below shows the modifications that are used during basic training. Similarly, Occupational Safety and Health Administration (OSHA) uses the same guidelines that are used in the US military to modify work for individuals involved in manual labor jobs such as construction workers, steel mill workers, firefighters, law enforcement officers, etc.

In addition to the US military and OSHA, school sanctioned athletics programs also use WBGT as a preventive measure against the heat. For example, the Georgia High School Athletics Association passed guidelines that mandate all state high schools measure WBGT and make necessary practice and game modifications depending on the WBGT reading. The guidelines are specific for the length of practice, number of breaks, and equipment that is allowed to be worn depending on WBGT temperature. The table below shows the guidelines that the Georgia High Schools must follow when exercising in the heat.

WBGT READING	ACTIVITY GUIDELINES & REST BREAK GUIDELINES
Under 82.0	Normal activities--Provide at least three separate rest breaks each hour of minimum duration of 3 minutes each during workout
82.0 - 86.9	Use discretion for intense or prolonged exercise; watch at-risk players carefully; Provide at least three separate rest breaks each hour of a minimum of four minutes duration each
87.0 - 89.9	Maximum practice time is two hours. For Football: players restricted to helmet, shoulder pads, and shorts during practice. All protective equipment must be removed for conditioning activities. For all sports: Provide at least four separate rest breaks each hour of a minimum of four minutes each
90.0 - 92.0	Maximum length of practice is one hour, no protective equipment may be worn during practice and there may be no conditioning activities. There must be 20-minutes of rest breaks provided during the hour of practice
Over 92.1	No outdoor workouts; Cancel exercise; delay practices until a cooler WBGT reading occurs

Work/Rest and Water Consumption Table

Applies to average sized, heat-acclimated soldier wearing BDU, hot weather. (See TB MED 507 for further guidance.)

Easy Work	Moderate Work	Hard Work
<ul style="list-style-type: none"> • Weapon Maintenance • Walking Hard Surface at 2.5 mph, < 30 lb Load • Marksmanship Training • Drill and Ceremony • Manual of Arms 	<ul style="list-style-type: none"> • Walking Loose Sand at 2.5 mph, No Load • Walking Hard Surface at 3.5 mph, < 40 lb Load • Calisthenics • Patrolling • Individual Movement Techniques, i.e., Low Crawl or High Crawl • Defensive Position Construction 	<ul style="list-style-type: none"> • Walking Hard Surface at 3.5 mph, ≥ 40 lb Load • Walking Loose Sand at 2.5 mph with Load • Field Assaults

- The work/rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hrs of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).
- **NL** = no limit to work time per hr.
- **Rest** = minimal physical activity (sitting or standing) accomplished in shade if possible.
- **CAUTION: Hourly fluid intake should not exceed 1½ qts.**
Daily fluid intake should not exceed 12 qts.
- If wearing body armor, add 5°F to WBGT index in humid climates.
- If doing Easy Work and wearing NBC (MOPP 4) clothing, add 10°F to WBGT index.
- If doing Moderate or Hard Work and wearing NBC (MOPP 4) clothing, add 20°F to WBGT index.

Heat Category	WBGT Index, F°	Easy Work		Moderate Work		Hard Work	
		Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)
1	78° - 81.9°	NL	¼	NL	¼	40/20 min	¼
2 (GREEN)	82° - 84.9°	NL	¼	50/10 min	¼	30/30 min	1
3 (YELLOW)	85° - 87.9°	NL	¼	40/20 min	¼	30/30 min	1
4 (RED)	88° - 89.9°	NL	¼	30/30 min	¼	20/40 min	1
5 (BLACK)	> 90°	50/10 min	1	20/40 min	1	10/50 min	1

For additional copies, contact: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division at (800) 222-9698 or CHPPM - Health Information Operations@apg.amedd.army.mil.
For electronic versions, see <http://chppm-www.apgea.army.mil/heat>. Local reproduction is authorized.
June 2004



CP-033-0404

When establishing WBGT guidelines for physical activity, the guidelines must be region (geographic) specific. For example, an athlete playing football in Louisiana may be accustomed to warm environmental conditions, unlike a football player from Maine. A football player practicing in 90°F temperatures in Louisiana could be comfortable whereas a football player practicing in the same conditions in Maine could be experiencing the worst conditions they have felt all year, which would increase the risk of heat illness.

Main Points

- WBGT has been shown to provide an accurate measure of environmental heat stress.
- WBGT can be used as a preventive measure during exercise in the heat by making activity modifications as WBGT rises.
- When developing guidelines for activity modification using WBGT, it is necessary to include work:rest ratios, length of activity, hydration breaks, equipment to be worn (if applicable), and a level in which activity is cancelled.
- WBGT guidelines must be region (geographic) specific since temperatures fluctuate differently by regions. People's response to exercising in heat may vary by the geographic region in which their usual exercise sessions take place.

References

1. Bergeron MF, McKeag DB, Casa DJ, et al. Youth football: heat stress and injury risk. *Med Sci Sports Exerc.* 2005;37(8):1421-1430.
2. Budd GM. Wet-bulb globe temperature (WBGT)—its history and its limitations. *J Sci Med Sport Sports Med Aust.* 2008;11(1):20-32.
3. Casa DJ, Guskiewicz KM, Anderson SA, et al. National athletic trainers' association position statement: preventing sudden death in sports. *J Athl Train.* 2012;47(1):96-118.
4. Grundstein AJ, Ramseyer C, Zhao F, et al. A retrospective analysis of American football hyperthermia deaths in the United States. *Int J Biometeorol.* 2012;56(1):11-20.
5. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med.* 2013;44(1):8-14.
6. Parsons K. Heat stress standard ISO 7243 and its global application. *Ind Health.* 2006;44(3):368-379.
7. Stearns R, O'Connor F, Casa D, Kenny G. Exertional Heat Stroke. In: Casa D, ed. *Preventing Sudden Death in Sport and Physical Activity.* Sudbury, MA: Jones & Bartlett; 2012.