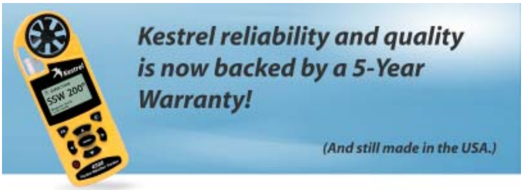
HEAT INDEX MANUAL



Nielsen-Kellerman

KESTREL® POCKET WEATHER™ TRACKER AIDS IN THE PREVENTION OF HEAT RELATED ILLNESS ....

With dangerous heat and humidity a major concern during summer training camps, the prevention of heat-related deaths and illnesses has become a priority with athletic coaches and trainers. The Kestrel 4000 Pocket Weather Tracker is an affordable, hand-held weather instrument that is capable of taking and logging critical heat stress index measurements whenever and wherever needed.

The Kestrel 4000 measures wind speed, temperature, wind chill, humidity, heat stress index, wet bulb temperature, barometric pressure, altitude, dewpoint, and density altitude. This allows coaches and trainers to take instantaneous temperature, humidity heat stress, and wet bulb temperature readings on the field with just the press of a button. Measurements taken on the field will provide far more accurate and relevant information than reliance upon local weather forecasts. Anyone participating in hot weather activities can use the Kestrel 4000 to assist in determining appropriate activity levels, rest intervals and hydration requirements, thereby preventing heat related health problems.

Jim Anderson, head athletic trainer for the St. Louis Rams, relies upon the accuracy of the Kestrel 4000. "Kestrel products are very helpful in monitoring weather conditions for our team in preparation for workouts and practices. For athletic trainers, safety is our primary goal and the Kestrel 4000 provides all of the information we need to determine if weather conditions are favorable for outdoor activities. Having quick access to temperature, humidity, wet bulb temperature, and heat index readings is critical to providing safe working conditions for our players."

The Kestrel 4000 can store data automatically at user-determined intervals, or manually with the press of a button. The 4000 stores and charts up to 2,000 sets of data, together with the date and time, for later review and record-keeping. A computer interface is also available, allowing users to upload the stored data for long-term storage and in-depth analysis. Durable , and easy-to-use, the Kestrel 4000 is completely waterproof and floats. It comes with neck and wrist lanyards and operates on 2 AAA batteries for approximately 400 hours of use.
Kestrels are assembled in the USA and fully guaranteed for FIVE years. Nielsen-Kellerman's Kestrel Weather division has been researching, developing and manufacturing technically advanced portable weather instruments for over eight years and owns multiple patents on their unique features.

Kestrel Pocket Weather Meters are employed by thousands of users in hundreds of demanding activities around the world. Other products in the Kestrel family include the Kestrel 1000, which measures solely wind speed, the Kestrel 2000 which measures wind speed, temperature and wind chill, Kestrel 2500, which measures wind speed, temperature, wind chill, barometric pressure and altitude, the Kestrel 3000, which measures wind speed, temperature, wind chill, relative humidity, heat stress index, and dewpoint, the Kestrel 3500, which measures wind speed, temperature, wind chill, relative humidity, heat stress index, dewpoint, barometric pressure, altitude and wet bulb temperature.

About the WBGT and Apparent Temperature Indices

http://www.bom.gov.au/info/thermal_stress/

Why are the indices useful?

We often use the air temperature as an indicator of how comfortable we will feel when involved in sports or other physical activities. However, the air temperature is only one factor in the assesment of thermal stress. In climates where other important factors, principally humidity, can vary widely from day to day, we need more than just the temperature for a more realistic assessment of comfort. However it is useful to be able to condense all the extra effects into a single number and use it in a similar way to the way we used the temperature. The Wet Bulb Globe Temperature(WBGT) and the Apparent Temperature are indices which attempt to do this.

What causes thermal stress?

Human thermal comfort depends on environmental and personal factors. **The four environmental factors are airflow (wind), air temperature, air humidity, and radiation from the sun and nearby hot surfaces.** The personal factors are the clothing being worn and the person's level of physical activity. Thermal sensation is also significantly affected by acclimatisation/adaptation: people living in hot climates have been shown to be comfortable at higher temperatures than those living in cooler climates.

In hotter conditions the body must shed heat to maintain thermal equilibrium. The cooling effect of evaporation of sweat from the skin becomes an important factor. The efficiency of this cooling depends on the humidity of the air. A high humidity reduces the effectiveness of evaporative cooling significantly. The amount of clothing will also affect this cooling efficiency due to its restriction of the air flow over the skin. Fabrics with low vapour permeability (those that don't "breathe") will increase the humidity of air near the skin.

In colder conditions, the body must either reduce heat loss (eg by taking shelter from the wind) or increase heat production, for example, by greater physical activity. In these conditons evaporation and air humidity are relatively unimportant factors. The cooling of the exposed parts of the body by the wind now becomes the most important external factor affecting thermal balance.

The effect of radiation is important under all temperature conditions. Excess radiation always acts to increase the heat load on a person. This can be of assistance under cold conditions, but under hot conditions it's an extra heat load that must be shed.

Of the four environmental factors, wind and radiation are very much influenced by the immediate surroundings. For example, wind speed is reduced by the sheltering effect of belts of trees and solar radiation is affected by short term localised phenomena such as cloudiness. If these factors are to be used as inputs, they are best measured on location, as values can vary significantly over relatively short distances. The remaining two factors (temperature and humidity) are less spatially variable and can be used to give an indication of the general comfort level of a region.

In order to make comparisons between areas, it is convenient to combine the effect of temperature and humidity into one index. This does not mean we can ignore the other environmental and non-environmental factors, but adjustments to the index value, either up or down, can be made to take them into account.

Most people use the temperature alone to provide some guide to the level of comfort. Generally this is quite reasonable because humidity doesn't often vary a lot, particularly in the tropics. However people moving from a less humid to more humid environment will immediately notice the effect of the greater humidity. In many sub-tropical regions of Australia the humidity is usually quite low, but occasionally can become quite high, again reducing comfort to those people not acclimatised.

The Wet Bulb Globe Temperature (WBGT) and Apparent Temperature (AT) are just two methods of combining temperature and humidity into a single number. In fact the real WBGT is also affected by wind and radiation, but the WBGT provided by the Bureau is only an approximation, which ignores variations of wind and radiation (light winds and fairly sunny conditions assumed). The AT can also be extended to take wind and solar radiation into account as well, though generally this is not done. In the AT values provided by the Bureau, wind is taken into account, but not solar radiation. Other indices such as the Physiologically Equivalent Temperature (PET) and the Predicted Mean Vote (PMV) can also be used.

The Wet Bulb Globe Temperature (WBGT)

The WBGT was developed in the late 1950s for the US Marine Corps Recruit Depot on Parris Island in South Carolina. Humidity in this region can be quite high and Marines have to undergo vigorous training exercise in military clothing, under full sun. There is a significant risk of heat injury if precautions are not taken.
The WBGT was later used by researchers as an easily measured general heat-stress index. In time its use widened. Because its use is recommended in the Standard, ISO 7243, it is often used in Occupational Health and Safety guidelines for working in hot environments. It has been advocated for use in sports requiring continuous exertion, such as the marathon. It is also used for horses in equestrian events. The WBGT is measured by a simple three-temperature element device similar to the picture.

Picture of a WBGT Instrument:
Courtesy of Richard de Dear, Macquarie University.

The first temperature, (Tg), is measured by the black globe thermometer, which usually consists of a 150 mm (6 inch) black globe with a thermometer located at the centre. The black globe temperature represents the integrated effects of radiation and wind.
The second thermometer (not easily viewed on the picture) measures the natural wet-bulb temperature (Tnwb). It consists of a thermometer with its bulb covered with a wettened cotton wick supplied with distilled water from a reservoir. Evaporation from the wettened bulb cools the thermometer. The natural wet-bulb thermometer, like the black globe thermometer is not shielded from wind or radiation. This thermometer represents the integrated effect of humidity, wind and radiation.
The final temperature element is the (shade) air temperature (Ta). It is measured by a thermometer shielded from radiation - generally by being placed in a weather screen. It is the standard temperature normally quoted in weather observations and forecasts.
The three elements Tg, Tnwb, and Ta are combined by into a weighted average to produce the WBGT.

$$\mathbf{WBGT = 0.7 \times Tnwb + 0.2 \times Tg + 0.1 \times Ta}$$

WBGT instruments are available commercially, but they are fairly expensive and require regular maintenance if they are to produce accurate values. **The Bureau of Meteorology does not have WBGT instruments at any of its observation sites**. Air temperature and humidity are measured using standard meteorological instruments and screened to shaded the instruments from the sun's radiation. Values for the black globe temperature and natural wet-bulb temperature cannot be accurately determined from a standard meteorological site.

Instead the Bureau uses an approximation to the WBGT. This approximation uses standard meteorologically measured temperature and humidity to calculate an estimation of the WBGT under moderately sunny light wind conditions. Real variations of sunshine and wind are not taken into account. The formula is likely to overestimate the WBGT in cloudy or windy conditions, or when the sun is low or below the horizon. Under clear full sun and low humidity conditions the approximation underestimates the WBGT slightly. The formula for the approximation is shown at the end of this document.

Although the WBGT is still widely used for heat stress measurements, the basis for its use as a model for human response to heat has been questioned. The effects of the four environmental factors on the WBGT do not necessarily match those of humans under all conditions. In modern heat stress research, sophisticated mathematical models of human response are more often used. The indices apparent temperature (AT), PET and PMV are all based on such heat balance models. These are too complex to be used in practice by organisations such as sports clubs, but are used by meteorologists for tasks such as computing climatologies of thermal sensation.

Because the Bureau of Meteorology uses an approximation to the WBGT, the user should clearly understand the limitations of this approximation as compared to a real measured WBGT. The fact that the values we produce assume a constant 'moderately sunny' day with 'light winds' may be overlooked, and it might be assumed that we have measured the true WBGT. This can cause confusion. **The Apparent Temperature (AT) (see below) does not have this ambiguity and consideration should be made as to whether this is a more appropriate guide for your activity.**

The Apparent Temperature (AT) - Heat Index

The apparent temperature (AT), invented in the late 1970s, was designed to measure thermal sensation in indoor conditions. It was extended in the early 1980s to include the effect of sun and wind. Only the modification due to wind is taken into account on this site. The AT index used here is based on a mathematical model of an adult, walking outdoors, in the shade (Steadman 1994). The AT is defined as; the temperature, at the reference humidity level, producing the same amount of discomfort as that experienced under the current ambient temperature and humidity.

Basically the AT is an adjustment to the ambient temperature (T) based on the level of humidity. An absolute humidity with a dewpoint of 14°C is chosen as a reference (this reference is adjusted a little with temperature). If the humidity is higher than the reference then the AT will be higher than the T; and, if the humidity is lower than the reference, then AT will be lower than T. The amount of deviation is controlled by the assumptions of the Steadman human model. In practice the AT is more intuitive to use than the WBGT, as it is an adjustment to the actual air temperature based on the perceived effect of the extra elements such as humidity and wind. AT is valid over a wide range of temperature, and it includes the chilling effect of the wind at lower temperatures - see below.

The hot weather version of the AT (1984) is used by the National Weather Service in the United States. In the United States this simple version of the AT is known as the Heat Index.

The AT used here does not include the effect of the sun, but this can be factored in. Under Australian conditions the effect of full sun produces a maximum increase in the AT of about 8°C when the sun is at its highest elevation in the sky.

The Apparent Temperature (AT) - Wind Chill

The apparent temperature (AT), described in the previous section, can also be used as a measure of wind chill. There are a number of Wind Chill Indices in use around the world, generally for colder temperatures than usually experienced in Australia. Nevertheless, conditions in parts of Australia can be cold enough, under windy conditions, to cause significant chilling. Below is a conversion table with a temperature range suitable for Australian conditions.

When using the AT as a wind chill the Steadman model assumes an appropriately dressed adult for those conditions. However if clothing were to get wet, the cooling effect would be greater than that predicted by this model, and the chance of hypothermia would be greater than indicated by the AT. In wet, windy conditions, someone wearing inadequate clothing can become hypothermic in quite mild temperatures.

Using the Indices

The heat indices on the observation page are only a guide to help you make decisions relating to your activity. Your decision process would need to include a number of factors of which temperature and humidity only form part.

For more details, sporting clubs should also obtain a copy of the Sports Medicine Australia Heat Policy. It can be downloaded for free from www.sma.org.au or www.coachesedge.com.au. The SMA Fact Sheet Beat the Heat - playing safely in hot weather and their brochure Drink up - Beat the heat are also useful. Sports Medicine Australia (SA) also have a booklet containing a Decision Checklist for sport in South Australia. The actual values might not be appropriate in all states but the methodology might be a useful guide. The booklet is available on the web as Hot Weather Guidelines .

By using the conversion tables below, and your own measurements it is possible to determine the value of the heat index at your venue. Care must be taken to correctly expose the temperature sensor. It should be about a metre above ground level, shaded and away from extraneous radiation sources (for example brick wall) so as to produce an accurate shade temperature. Compare your maximum temperature with a nearby reference weather station. If your value is consistently high, for a reason you can't explain, try another location.
To estimate the average conditions of the index you can use the Bureau of Meteorology climate data. Click on the Climate Averages link. You will need to get averages of temperature and relative humidity. On the lower part of the Climate Averages page, choose your state, lookup the nearest observation site to your location, click on the station number. For afternoon conditions you should use the Mean Daily Maximum Temperature and Mean 3pm Relative Humidity. Do not use this relative humidity for other times because relative humidity changes quite a bit during the day.

For example if we choose BRISBANE REGIONAL OFFICE, in January we have a temperature of 29.4°C and relative humidity of 59%. From the tables this gives an apparent temperature of about 32°C and a WBGT of about 30°C.

Conversion Tables:

Apparent temperature (AT) from temperature and relative humidity - after Steadman 1994

Temperature (°C)

Relative Humidity (%)	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
5	16	17	18	19	20	21	22	23	24	25	26	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	44	45	46	47	48
10	17	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34	35	36	37	38	39	41	42	43	44	45	46	48	49	50
15	17	18	19	20	21	22	24	25	26	27	28	29	30	31	33	34	35	36	37	38	40	41	42	43	45	46	47	48	50		
20	17	18	20	21	22	23	24	25	26	28	29	30	31	32	33	35	36	37	38	40	41	42	43	45	46	47	49	50			
25	18	19	20	21	22	24	25	26	27	28	29	31	32	33	34	36	37	38	40	41	42	44	45	46	48	49					
30	18	19	21	22	23	24	25	26	28	29	30	31	33	34	35	37	38	39	41	42	43	45	46	48	49						
35	19	20	21	22	23	25	26	27	28	30	31	32	34	35	36	38	39	40	42	43	45	46	48	49							
40	19	20	21	23	24	25	26	28	29	30	32	33	34	36	37	39	40	41	43	44	46	48	49								
45	19	21	22	23	24	26	27	28	30	31	32	34	35	37	38	40	41	43	44	46	47	49									
50	20	21	22	24	25	26	28	29	30	32	33	35	36	38	39	41	42	44	45	47	49	50									
55	20	22	23	24	25	27	28	30	31	32	34	35	37	38	40	42	43	45	46	48	50										
60	21	22	23	25	26	27	29	30	32	33	35	36	38	39	41	42	44	46	48	49											
65	21	22	24	25	27	28	29	31	32	34	35	37	39	40	42	43	45	47	49												
70	21	23	24	26	27	28	30	31	33	35	36	38	39	41	43	44	46	48	50												
75	22	23	25	26	28	29	31	32	34	35	37	38	40	42	44	45	47	49													
80	22	24	25	27	28	30	31	33	34	36	38	39	41	43	45	46	48	50													
85	23	24	26	27	29	30	32	33	35	37	38	40	42	44	45	47	49														
90	23	25	26	28	29	31	32	34	36	37	39	41	43	45	46	48	50														
95	23	25	26	28	30	31	33	35	36	38	40	42	43	45	47	49															
100	24	25	27	29	30	32	33	35	37	39	41	42	44	46	48	50															

AT above 50°C

Wet Bulb Globe Temperature (WBGT) from Temperature and Relative Humidity

Temperature (°C)

Relative Humidity (%)	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	15	16	16	17	18	18	19	19	20	20	21	22	22	23	23	24	24	25	25	26	27	27	28	28	29	29	30	31	31	32	32
5	16	16	17	18	18	19	19	20	21	21	22	22	23	24	24	25	26	26	27	27	28	29	29	30	31	31	32	33	33	34	35
10	16	17	17	18	19	19	20	21	21	22	23	23	24	25	25	26	27	27	28	29	30	30	31	32	32	33	34	35	36	36	37
15	17	17	18	19	19	20	21	21	22	23	23	24	25	26	26	27	28	29	29	30	31	32	33	33	34	35	36	37	38	39	
20	17	18	18	19	20	21	21	22	23	24	24	25	26	27	27	28	29	30	31	32	32	33	34	35	36	37	38	39			
25	18	18	19	20	20	21	22	23	24	24	25	26	27	28	28	29	30	31	32	33	34	35	36	37	38	39					
30	18	19	20	20	21	22	23	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36	37	39							
35	18	19	20	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39								
40	19	20	21	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39									
45	19	20	21	22	23	24	25	26	27	27	28	29	30	32	33	34	35	36	37	38											
50	20	21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	39												
55	20	21	22	23	24	25	26	27	28	29	30	31	32	34	35	36	37	38													
60	21	22	23	24	25	26	27	28	29	30	31	32	33	35	36	37	38														
65	21	22	23	24	25	26	27	28	29	31	32	33	34	36	37	38															
70	22	23	24	25	26	27	28	29	30	31	33	34	35	36	38	39															
75	22	23	24	25	26	27	29	30	31	32	33	35	36	37	39																
80	23	24	25	26	27	28	29	30	32	33	34	36	37	38																	
85	23	24	25	26	28	29	30	31	32	34	35	37	38	39																	
90	24	25	26	27	28	29	31	32	33	35	36	37	39																		
95	24	25	26	27	29	30	31	33	34	35	37	38																			
100	24	26	27	28	29	31	32	33	35	36	38	39																			

WBGT > 40

Note: This table is compiled from an approximate formula which only depends on temperature and humidity. The formula is valid for full sunshine and a light wind

About the approximation to the WBGT used by the Bureau of Meteorology

The approximation used by the Bureau of Meteorology does not take into account variations in the intensity of solar radiation or of windspeed, and assumes a moderately high radiation level in light wind conditions.
Use of this approximation may lead to incorrect estimates of thermal stress, particularly in cloudy and windy conditions. Under these conditions the approximation is likely to lead to an overestimate of the stress. The approximation will also overestimate night-time and early morning conditions when the sun is low or below the horizon.
The simplified formula is:

$$\mathbf{WBGT = 0.567 \times Ta + 0.393 \times e + 3.94}$$

where:
Ta= Dry bulb temperature (°C)
e= Water vapour pressure (hPa) [humidity]
The vapour pressure can be calculated from the temperature and relative humidity using the equation:
$e = rh / 100 \times 6.105 \times \exp (17.27 \times Ta / (237.7 + Ta))$
where: rh= Relative Humidity [%]

Source: American College of Sports Medicine, Prevention of thermal injuries during distance running - Position Stand. Med.J.Aust. 1984 Dec. 876
About the formula for the apparent temperature
The formula for the AT used by the Bureau of Meteorology is an approximations of the value provided by a mathematical model of heat balance in the human body. It can include the effects of temperature, humidity, wind-speed and radiation. Two forms are given, one including radiation and one without. On this site we use the non-radiation version.
Version including the effects of temperature, humidity, and wind:
$AT = Ta + 0.33 \times e - 0.70 \times ws - 4.00$
Version including the effects of temperature, humidity, wind, and radiation:
$AT = Ta + 0.348 \times e - 0.70 \times ws + 0.70 \times Q/(ws + 10) - 4.25$
where:
Ta= Dry bulb temperature (°C)
e= Water vapour pressure (hPa) [humidity]
ws= Wind speed (m/s) at an elevation of 10 meters
Q= Net radiation absorbed per unit area of body surface (w/m2)

The vapour pressure can be calculated from the temperature and relative humidity using the equation:
$e = rh / 100 \times 6.105 \times \exp (17.27 \times Ta / (237.7 + Ta))$
where:
rh= Relative Humidity [%]

By Jack Williams, USATODAY.com

Blistering summer heat waves can be not only extremely uncomfortable, but even deadly, as Europe learned during the summer of 2003.

History shows that heat waves are deadliest in large cities that rarely experience hot weather, with the elderly and those in poor health in the greatest danger.

In recent years, scientists have learned that a day's highest temperature is not the best measure of the danger of heat waves. Unrelenting heat that doesn't allow people to rest at night is responsible for the deaths of many elderly and ill people.

Recognition of this danger led the U.S. National Weather Service to begin using a new mean heat index.

Heat, humidity add up to danger

The elderly and ill aren't the only people that heat kills. It also kills healthy young people, usually because they do not recognize the dangers of exercising in hot weather, especially hot, humid weather.
When heat and humidity combine to slow evaporation of sweat from the body, outdoor exercise becomes dangerous even for those in good shape.

Key rules for coping with heat are to drink plenty of water to avoid dehydration and to slow down and cool off when feeling fatigued, a headache, a high pulse rate or shallow breathing. Overheating can cause serious, even life-threatening conditions such as heat stroke.

Dangers of heat include

* Heat cramps: Exercising in hot weather can lead to muscle cramps, especially in the legs, because of brief imbalances in body salts. Cramps become less frequent as a person becomes used to the heat.
* Heat syncope or fainting: Anyone not used to exercising in the heat can experience a quick drop in blood pressure that can lead to fainting. As with heat cramps, the cure is to take it easy.
* Heat exhaustion: Losing fluid and salt through perspiration or replacing them in an imbalanced way can lead to dizziness and weakness. Body temperature might rise, but not above 102 degrees. In some cases victims, especially the elderly, should be hospitalized. Heat exhaustion is more likely after a few days of a heat wave than when one is just beginning. The best defense is to take it easy and drink plenty of water. Don't take salt tablets without consulting a physician.
* Heatstroke: In some cases extreme heat can upset the body's thermostat, causing body temperature to rise to 105 degrees or higher. Symptoms are lethargy, confusion and unconsciousness. Even a suspicion that someone might be suffering from heatstroke requires immediate medical aid. Heatstroke can kill.

Extreme danger | Danger | Extreme caution | Caution

Apparent temperature *is how hot the heat-humidity combination makes it feel.*

RELATIVE HUMIDITY (PERCENT) / AIR TEMPERATURE (DEGREES FAHRENHEIT)

	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
140	125																				
135	120	128																			
130	117	122	131																		
125	111	116	123	131	141																
120	107	111	116	123	130	139	148														
115	103	107	111	115	120	127	135	143	151												
110	99	102	105	108	112	117	123	130	137	143	150										
105	95	97	100	102	105	109	113	118	123	129	135	142	149								
100	91	93	95	97	99	101	104	107	110	115	120	126	132	138	144						
95	87	88	90	91	93	94	96	98	101	104	107	110	114	119	124	130	136				
90	83	84	85	86	87	88	90	91	93	95	96	98	100	102	106	109	113	117	122		
85	78	79	80	81	82	83	84	85	86	87	88	89	90	91	93	95	97	99	102	105	108
80	73	74	75	76	77	77	78	79	79	80	81	81	82	83	85	86	86	87	88	89	91
75	69	69	70	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80
70	64	64	65	65	66	66	67	67	68	68	69	69	70	70	70	71	71	71	71	71	72

Source: National Oceanic and Atmospheric Administration

Heat and humidity can be deadly combination

Hot, humid weather is more uncomfortable than hot, dry weather because high humidity slows the evaporation of sweat. Evaporation is nature's way of cooling. Hot, humid weather is not only uncomfortable, it's dangerous to those exercising in it. The table here shows how to find the "apparent temperature," that is, how hot various temperature-humidity combinations feel. For example, if the temperature is 95 and the relative humidity is 50 percent, find 95 in the temperature column on the left side, follow that row to the right to the 50 percent humidity column. The apparent temperature is 107. This falls into the "danger" area where outdoor exercise isn't a wise idea. The colors on the chart show the level of danger of various combinations. To see what these mean, go to the heat stress index. The humidity calculations page now has the detailed formulas for calculating the heat index, or apparent temperature.

Which Kestrel is Best for You?

Kestrel® Pocket Weather® Meters
www.nk.com.au

Available Functions	 1000	 2000	 2500	 3000	 3500
Current Wind Speed	■	■	■	■	■
Max Wind Gust	■	■	■	■	■
Avg Wind Speed	■	■	■	■	■
Volume Air Flow					
Temperature		■	■	■	■
Wind Chill		■	■	■	■
Relative Humidity				■	■
Heat Stress Index				■	■
Dewpoint Temp				■	■
Wet Bulb Temp					■
Humidity Ratio					
Evaporation Rate					
Delta T					
Barometric Pressure			■		■
Absolute Pressure					
Altitude			■		■
Air Density					
Density Altitude					
Digital Compass					
Wind Direction					
Crosswind					
Headwind/Tailwind					
Backlit Display		■	■	■	■
Pressure Trend			■		■
Data Storage & Charting					
Data Upload					
Clock			■		■
NV Model Available			■		■

						
3500 DeltaT	**4000**	**4100**	**4200**	**4250**	**4300**	**4500**
■	■	■	■	■	■	■
■	■	■	■	■	■	■
■	■	■	■	■	■	■
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Heat Index

SR 90-23
Technical Attachment 7/1/90

The Heat Index "Equation"

(or, More Than You Ever Wanted to Know About Heat Index)

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Now that summer has spread its oppressive ridge over most of the Southern Region, NWS phones are ringing off their hooks with questions about the Heat Index. Many questions regard the actual equation used in calculating the Heat Index. Some callers are satisfied with the response that it is extremely complicated. Some are satisfied with the nomogram (see Attachment 1). But there are a few who will settle for nothing less than the equation itself. No *true* equation for the Heat Index exists. Heat Index values are derived from a collection of equations that comprise a model. This Technical Attachment presents an equation that approximates the Heat Index and, thus, should satisfy the latter group of callers.

The Heat Index (or apparent temperature) is the result of extensive biometeorological studies. The parameters involved in its calculation are shown below (from Steadman, 1979). Each of these parameters can be described by an equation but they are given assumed magnitudes (in parentheses) in order to simplify the model.

Vapor pressure. Ambient vapor pressure of the atmosphere. (1.6 kPa)
Dimensions of a human. Determines the skin's surface area. (5' 7" tall, 147 pounds)
Effective radiation area of skin. A ratio that depends upon skin surface area. (0.80)
Significant diameter of a human. Based on the body's volume and density. (15.3 cm)
Clothing cover. Long trousers and short-sleeved shirt is assumed. (84% coverage)
Core temperature. Internal body temperature. (98.6°F)
Core vapor pressure. Depends upon body's core temperature and salinity. (5.65 kPa)
Surface temperatures and vapor pressures of skin and clothing. Affects heat transfer from the skin's surface either by radiation or convection. These values are determined by an iterative process.
Activity. Determines metabolic output. (180 W m-2 of skin area for the model person walking outdoors at a speed of 3.1 mph)
Effective wind speed. Vector sum of the body's movement and an average wind speed. Angle between vectors influences convection from skin surface (below). (5 kts)
Clothing resistance to heat transfer. The magnitude of this value is based on the assumption that the clothing is 20% fiber and 80% air.
Clothing resistance to moisture transfer. Since clothing is mostly air, pure vapor diffusion is used here.
Radiation from the surface of the skin. Actually, a radiative heat-transfer coefficient determined from previous studies.
Convection from the surface of the skin. A convection coefficient also determined from previous studies. Influenced by kinematic viscosity of air and angle of wind.

Sweating rate. Assumes that sweat is uniform and not dripping from the body.
As an aside, these assumptions are important for the forecaster to keep in mind. For example, a common perception is that wind is not taken into account in the Heat Index. In actuality it is. It is assumed to be 5 knots. This may seem trivial but a forecaster may be able to use this information creatively when writing Public Information Statements regarding heat stress, heat stroke, etc.
Ventilation rate. The amount of heat lost via exhaling. (2-12%, depending upon humidity)
Skin resistance to heat transfer. A function of activity, skin temperature, among others.
Skin resistance to moisture transfer. A function of the vapor-pressure difference across the skin (and, therefore, relative humidity). It decreases with increasing activity.
Surface resistance to heat transfer. As radiation and convection from the skin increases, this value decreases.
Surface resistance to moisture transfer. Similar to heat transfer resistance but also depends upon conditions in the boundary layer just above skin's surface.

These last five variables are used explicitly to derive the apparent temperature. By an iterative procedure which relies on the assumptions in the first list, the model is reduced to a relationship between dry bulb temperature (at different humidities) and the skin's resistance to heat and moisture transfer. Since these resistances are directly related to skin temperature, we now have a relationship between ambient temperature and relative humidity versus skin (or apparent) temperature. As a result of this procedure, there is a base relative humidity at which an apparent temperature (e.g., 90°F) "feels" like the same air temperature (90°F). Increasing (decreasing) humidity and temperature result in increasing (decreasing) apparent temperature, and, yes, apparent temperature *can* be lower than air temperature. Steadman (1979) developed a table based on this relationship and the nomogram in Attachment 1 summarizes that table.

In order to arrive at an equation which uses more conventional independent variables, a multiple regression analysis was performed on the data from Steadman's table. The resulting equation could be considered a Heat Index equation, although it is obtained in a "round-about" way. Thus, here is an ersatz version of the Heat Index equation:

HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783x10-3T2
- 5.481717x10-2R2 + 1.22874x10-3T2R + 8.5282x10-4TR2 - 1.99x10-6T2R2

where T = ambient dry bulb temperature (°F)
R = relative humidity (integer percentage).
Because this equation is obtained by multiple regression analysis, the heat index value (HI) has an error of ±1.3°F. Even though temperature and relative humidity are the only two variables in the equation, all the variables on the lists above are implied.

References
Steadman, R.G., 1979: The assessment of sultriness. Part I: A temperature-humidity index based on human physiology and clothing science. *J. Appl. Meteor.*, **18**, 861-873.

Staying Healthy in the Heat

http://www.armymedicine.army.mil/hc/healthtips/13/200305-06healthyinheat.cfm
Healthcare & Tricare - Health Tips - Military

Summer months bring to mind vacations, school breaks and warmer temperatures. Summer months also mean new challenges for staying healthy and preventing heat injuries and illnesses.

Individuals who are not adequately hydrated and acclimated to their environment or who are in poor physical condition are most at risk for heat injuries or illnesses, say experts. However, heat injuries and illnesses can be avoided in most circumstances.

Heat injuries and illnesses may be prevented if people are knowledgeable of the signs and symptoms of heat illnesses as well as alert to environmental conditions.

People should plan carefully for any event involving sequential days of high-performance training, remain hydrated, and dress in appropriate warm-weather clothing permitting air circulation between the skin and material of the clothing. Becoming acclimatized to the area or region, especially for people new to the location, is important. Ideally, if the situation permits, people should avoid outdoor activities during the hottest part of the day, usually between noon and 3 p.m.

While it's important not to overexert yourself and gradually work the body up to a level of fitness over time, it is just as important to avoid the use of supplements such as ephedra or ma-huang, commonly found in fat burners. These substances may adversely affect the body's cooling mechanism during strenuous physical training. Select beverages free of caffeine and alcohol.

Also, if you are on antihistamines or other medications, your risk for heat illness increases.

Individuals who have experienced a previous heat injury or illness tend to be at an increased risk for subsequent injuries or illnesses as well. People who have had a previous heat injury need to be identified so additional preventive measures can be taken to reduce the risk of a subsequent heat injury or illness.

Individuals who are overweight or not physically fit; are suffering from an acute or chronic infection or febrile condition; recently had an immunization; are experiencing diarrhea; have conditions affecting sweat secretions such as a sunburn, chronic use of diuretics, or medications that inhibit sweating (atropine, antihistamines, some tranquilizers, cold medicines and some antidiarrheal medications)—such individuals are all at an increased risk for heat illnesses.

In the military, there are actions commanders can do to help soldiers stay healthy as the weather warms up and the heat index rises. Commanders need to ensure soldiers stay hydrated, eat all meals, wear uniforms properly, use sunscreen, and stay alert to the signs and symptoms of heat illness. They should also implement the work/rest cycle if the tactical situation permits and consider delaying heavy work such as foxhole construction until the cooler hours of the day—mornings or evenings.

Leaders need to know not all soldiers are at the same level of fitness or conditioning level. It is important to know which soldiers are new to the unit so proper levels of exercise can be identified for these troops to facilitate acclimation. Troops not properly acclimated to their new environment are at an increased risk for heat injuries and illnesses.

During the first two days of heat exposure, light activities such as softball or a slow jog would be appropriate. By the third day of heat exposure, a two-mile unit run at the pace of the slowest participant is feasible.

Leaders should gradually increase the intensity of the exercise each day, working up to an appropriate physical training schedule adapted for the environment. Maintenance-level PT programs should be conducted in the evening or night.

However, people who are not physically exerting themselves may also be at risk. Rested, well-trained soldiers working on sedentary tasks should be able to work normally in the heat for up to four hours under hot conditions. However, after this amount of time intellectual performance may steadily deteriorate.

Tasks requiring sustained attention such as watching radarscopes and sentry duty are at greater risk for heat injury or illness. Other tasks which are monotonous, repetitive, or boring; tasks which require attention to detail and short-term memory such as calculations, map plotting, and coding messages; tasks which must be done quickly or according to a fixed schedule; tasks which require arm-hand steadiness; and command and control tasks where confusion and misinformation are common may be impacted negatively in hot environments. Simply put, reaction and decision times are slower in the heat.

There are three fairly distinct clinical syndromes associated with heat—heat cramps, heat exhaustion and heat stroke. Typically, the body is able to regulate internal temperatures within a narrow range quite well. However, as we become more active, the heat stress load increases, requiring the body to lose heat in order to maintain this optimal internal temperature range.

Heat cramps are muscle cramps, primarily in the abdomen, legs and arms. This condition is due to excessive salt and water losses. Heat cramps most often occur in soldiers who are not acclimatized to the heat and can generally be avoided by maintaining proper nutrition and hydration.

Heat exhaustion signs and symptoms may include fatigue, nausea, dizziness, fainting, vomiting, mild changes in mental function such as disorientation or irritability, and an elevated temperature. Heat exhaustion can be avoided by employing appropriate work/rest cycles, maintaining full hydration and ensuring individuals are properly acclimated to their environment.

Heat stroke may include some or all of the above-mentioned signs and symptoms, but is more severe and can be fatal. The victim will be hot and disoriented or unconscious. Employing work/rest cycles and maintaining full hydration can avoid heat stroke.

People should watch for signs of overheating including inability to work, red or flushed face, confusion or disorientation, fainting or collapse.

If a soldier is incoherent or unconscious and hot, the soldier may have heat stroke. This heat illness is a medical emergency of the highest priority for medical evacuation.

Heat-stricken soldiers should immediately be moved into shade and any heavy clothing and equipment should be removed. If the victim is alert and not vomiting, have him or her drink water slowly. If enough water is available, wet the T-shirt and fan the soldier for cooling.

Immersion in cool or iced water is the quickest way of lowering the body's temperature. A field immersion device can be built from tent canvas mounted in a frame off the ground. The water can then evaporate from the canvas helping to cool the individual. If an above-ground frame cannot be constructed, a shallow pit lined with canvas can be used.

For heat cramps, rehydration should be done with liquids such as sports drinks containing electrolytes. If the victim can drink, he or she should be given up to 1.5 quarts per hour using an oral rehydration solution or water. Sports drinks containing glucose/electrolytes are best.

For more information about how to prevent heat injuries or illnesses contact your unit field sanitation team, the unit's supporting preventive medicine section, preventive medicine detachment, division preventive medicine/surgeon's office, or the preventive medicine staffs at your supporting medical treatment facility.

(Information provided by Landstuhl Regional Medical Center, Germany. Lt. Col. Michael Swalko, environmental science officer, provided technical expertise.)

Preventing Heat Illness in Sport

http://www.sma.org.au/

The object of this document is to prevent injury, and possible death, from heat illness in sport and activity by assisting officials, coaches and participants to recognise and manage potentially dangerous heat situations. This is achieved by:

1. Alerting sporting bodies and participants of the risk of heat illness from physical activity in hot weather conditions.
2. Providing a clear cancellation policy for sporting bodies conducting events in hot weather conditions
3. Educating sporting bodies and participants on methods of minimising the risk of heat illness and the avoidance of situations that may worsen heat illness.Wet Bulb Globe Temperature (WBGT) is the best measure of heat strain currently available. WBGT is not the same as Ambient or 'Dry' temperature as the WBGT accounts for the levels of humidity, radiation, wind movement and ambient temperature.WBGT should be measured on site immediately prior to the start of an activity or event using a specific WBGT thermometer. This is done to ensure measurements are reflective of the conditions at which the event is to be played.

HOT WEATHER POLICY FOR THE GENERAL POPULATION

At WBGT greater than 28 degrees Celsius there is extreme risk of heat injury to all participants. Sporting events or activities requiring moderate to intense exercise that are conducted in conditions that exceed 28 degrees WBGT should be postponed or cancelled. Activity may be undertaken by individuals who are not categorised in any of the "at risk" groups if conditions are equivalent to the following WBGT ranges. However, strategies to reduce the risk of heat injury should be implemented particularly when high or moderate risk of heat injury is apparent.• At WBGT between 23 and 28 degrees Celsius there is a high risk of heat injury.• At WBGT between 18 and 22 degrees Celsius there is a moderate risk of heat injury• At WBGT below 18 degrees Celsius there is a minimal risk of heat injury.

DISCUSSION

The risk of heat injury from high intensity sport is significant. It can range from cramps, through heat exhaustion to heat stroke, coma, and death (Mitchell, 1994). During a competition, a competitor may produce 15 - 20 times the heat they produce at rest. Dissipation of this excess heat is primarily achieved through sweating. If the body's ability to dissipate heat is compromised, core temperature in an average size individual may rise by one degree Celsius for every five minutes of exercise if no temperature regulating mechanisms are activated (Nadel 1977). If an individual's core temperature is above 40 degrees Celsius (normal 37 degrees) the risk of heat injury is significant. Factors which impair the body's ability to dissipate heat are:

1. High ambient temperature2. Solar radiation3. Humidity (this compromises the efficacy of sweating)4. DehydrationThese factors significantly increase the risk of heat injury occurring.

STRATEGIES FOR REDUCING THE RISK OF HEAT ILLNESS (General Population)

The following strategies are intended for the general population that does not fall into any of the listed 'At Risk' categories. 'At Risk' participants should consult the recommendations for their particular population sector.

1.Timing of Games and sporting activities involving moderate to high intensity exercise should be scheduled to avoid conditions where WBGT exceeds or is likely to exceed 28 degrees Celsius.In most parts of Australia players are likely to be exposed to their highest risk of heat injury in the months of December, January and February, although in some regions this level of risk extends into March and April. This is in part due to high ambient temperatures that are prevalent during this period, and lack of match fitness of players participating in traditional winter sports such as Australian Rules Football. Where possible, especially in January and February, games should be scheduled to start before 9 a.m. or after 6 p.m. Early morning or night games minimise the risk of encountering unacceptable conditions at these times of year. This is especially so where these games are to be played in a locations with a history of relatively high WBGT.

2. Acclimatisation If games or activities are to be conducted after long periods of cooler conditions participants should strive to be fully acclimatised prior to participation. Physiological adaptations to exercising in the heat are rapid and can occur after 3-5 days in a hot environment.

Full acclimatisation can take 10-14 days or longer. The initial response is an expansion of the plasma volume, then over several days, this returns to normal and the sweat rate increases with sweating starting earlier and a more dilute sweat being produced. There is evidence that exercising in sweat clothing to the point where heat strain is induced can give some degree of acclimatisation (Dawson,et.al.). The training must induce heat strain over several days, and care must be taken that adequate hydration occurs during these training sessions.Doing some form of submaximal exercise in a heat chamber will also give some degree of acclimatisation; but
its practicality in a team sport, except possibly in individual cases, is limited.Some level of acclimatisation will occur in players coming out of summer. This, however, is usually countered by the lack of match fitness in athletes at this time of year.What can be done easily is to educate athletes to train themselves to play and train with copious fluids already on-board. Further it must be emphasised to the players that they MUST consume fluids containing 6-8% carbohydrate - in warm/hot conditions, muscle glycogen utilisation is much higher. (Febbraio, 1992). The consumption of carbohydrate containing fluids such as Gatorade has been proven to improve performance in the heat and, more importantly, delay the onset of Exercise-Induced Heat Exhaustion (Febbraio,1992, Davies etal. 1988) and, hence, probably help prevent Heat Stroke.

3. Hydration The more an athlete sweats, the more fluid he must consume to avoid dehydration. High levels of dehydration may increase the risk of heat stress. To diminish the risk of heat stress fluid should be consumed before, during and after activity. It is recommended participants drink at least 7-8ml of fluid per kg of body mass no more than 2 hours before exercising to promote adequate hydration and allow time for excretion of excess water.During exercise it is recommended that participants should drink fluid at regular intervals to replace water lost through sweating. Participants should aim to drink at least 3ml per kg of body mass (about 250ml for the average athlete of around 70 kilograms every 15 to 20 minutes). However this may vary dependent on the rate of sweating. Fluid taken should be cooler than the ambient temperature.Water is considered an adequate fluid option for activities lasting up to one hour although there is evidence that sports drinks such as Gatorade do provide a benefit for exercise that is less than one hour in duration. Participants in events or activities exceeding one hour are recommended to use carbohydrate based sports drinks such as Gatorade as a means of replacing fluids, carbohydrates and electrolytes lost during prolonged activity.In high risk conditions players should be encouraged to drink fluids at scheduled drinks breaks and should be provided convenient access to fluids during activity without unnecessary interruption to the game or event. Officials and event organisers should also consider including additional drinks breaks for players in conditions of high risk.In regard to post-event rehydration, it needs to be remembered that this can take 24 hours or more.

4. Player Rest and Rotation In conditions of high risk participants should be provided opportunities to rest through the use of player interchange or substitution. The period of rest should be determined by the WBGT at the time of the event or activity. For WBGT temperatures greater than 18 degrees Celsius and less than 23 degrees Celsius all players should be rested for at least 10% of the period they would normally participate. For example, if the activity normally runs for 60 minutes the rest period for the player should comprise at least 6 minutes during the period. For situations where the WBGT is greater than 23 degrees Celsius and less than 28 degree Celsius, all players should be rested for at least 25% of the period they would normally participate.This may be achieved by rotation of players through an interchange bench or via the reduction in the regular playing time for all players.For events played in high risk conditions that do not have a specified playing time, players should be permitted to take rest breaks from activity equivalent to 3 minutes for every 30 minutes of activity.The positive effects of rest breaks should also be maximised by employing the following strategies:• Allowing players to rest in naturally shaded areas, or providing portable structures that create shade where and when required • Providing fans and ice packs• Providing additional fluids to allow participants to spray or douse themselves to assist cooling.

5. Pre-cooling Pre-cooling by cool water immersion or the wearing of ice vests has been demonstrated to increase athletic performance in endurance sports. This practice could be of benefit to many athletes. However, it must be noted that the effects of a pre-cooling manoeuvre are reduced rapidly by a warm up. Therefore, any pre-cooling strategy must be undertaken in concert with a vastly reduced warm-up if it is to be effective.

6. Clothing Light coloured, loose fitting clothes, of natural fibres or composite fabrics, with high wicking (absorption) properties, that provide for adequate ventilation are recommended as the most appropriate clothing in the heat. This clothing should further complement the existing practices in Australia that protect the skin against permanent damage from the sun.

CHILDREN AND HEAT The physiological and structural difference between children and adults places children at a greater risk of suffering from heat illness. These differences impact on a child's ability to respond to environmental heat and acclimatise to heat. These differences include: • A larger surface area/body mass ratio which affects their ability to dissipate heat when environmental temperature is greater than skin temperature (Falk 1998). This can be an advantage when heat loss is necessary, but is a disadvantage when radiant or convective heat gain occurs.• Immature sweating mechanisms which require a greater increase in body temperature before the onset of sweating (Araki et al 1979)• Fewer and smaller sweat glands which limits the production of sweat (Araki et al., 1979, Falk, 1998, Wagner et al., 1974

HOT WEATHER POLICY FOR CHILDREN At ambient temperature greater than or equal to 34 degrees Celsius there is extreme risk of heat injury to all children and adolescents participants Events and activities involving children and adolescents that are conducted or scheduled for times likely to present conditions where the ambient air temperature is greater than or equal to 34 degrees Celsius, should be postponed or cancelled.

STRATEGIES FOR REDUCING THE RISK OF HEAT ILLNESS (Children) The following strategies should be considered for sport and physical activities involving children. The strategies should be considered in conjunction with strategies for reducing the risk of heat illness for the general population and the hot weather policy for children.

1. Shade and Drinks Organisers of activities that are conducted under hot conditions must provide sufficient shade, and regular drinking opportunities. This is particularly critical where the fitness and state of acclimatization of the young participants are uncertain.It is recommended that water or sports drinks such as Gatorade be provided whenever children are being active. More fluid however, appears to be consumed by young people when the drinks offered are perceived as palatable to them. Therefore, for children and adolescents having trouble drinking adequate tap water, flavoured drinks such as commercially available sports drinks may need to be considered. Conversely, the high energy content of some flavoured drinks may be unnecessary during exercise in athletes who have a genuine rather than an aesthetic need to lower body fat levels. It is recommended that young athletes begin regular drinking routines using water or sports drinks such as Gatorade during training and competition. Regular and effective drinking practices should become habitual to young athletes before, during, and after activity. Individuals should monitor weight changes before and after workouts and know the amount of fluid that they are likely to require. The electrolyte content of some sports drinks consumed following activity may shorten the time taken to recover, particularly in well-trained young athletes who sweat considerably more than their sedentary peers.

2. Acclimatisation and Overweight Children In addition to the risks associated with activity in the heat for unfit and unacclimatised young people, coaches/supervisors of overweight children and adolescents should take extra precautions to lessen the potential for heat gain. It is recommended that whenever activity in hot conditions is unavoidable with these children, coaches /supervisors decrease the volume and duration of physical activity, and increase opportunities for drinking, rest, and shade as a matter of priority. At the onset of hot weather, the young athlete may take longer to acclimatize. It is therefore recommended that training volumes (duration and intensity) decrease during the first few weeks of hot weather. Increased times for rest, using access to shade more frequently, and increasing the number of mandatory drinking breaks are recommended for the young athlete when the weather becomes noticeably hotter.

3. Clothing In addition to the clothing recommendations made for the general population, it is recommended that summer based sporting organizations select uniforms that minimize heat gain and that coaches, teachers, and parents encourage children and adolescents to wear appropriate clothing in layers that can be easily removed during activity.

4. Heat Illness Register To improve the understanding of children and adolescents activity in the heat, it is recommended that a register of heat-related illness be established. This may comprise a system within which all aspects of heat related illness incidents are recorded. Items of note may include the individual afflicted and their symptoms, the time of the incident, the environmental conditions, the physical activity undertaken, the immediate treatment and subsequent action taken. The system is recommended to aid in the identification of individuals that have previously experienced some form of heat illness and therefore may require additional attention to ensure prevention strategies are adopted by these individuals.

RECOMMENDATIONS FOR THE DEVELOPMENT AND IMPLEMENTATION OF SPORTS INDUSTRY STRUCTURES TO REDUCE THE RISK OF HEAT ILLNESS

Wet Bulb Globe Temperature and its measurement are not currently considered in Australian sport except in a small number of isolated elite sporting competitions and events. The adoption of policies (General Population) that require the use of Wet Bulb Globe Temperature as the defining measurement for decisions relating to the cancellation of events are recognised as being difficult to implement . At present, issues such as cost, convenience and availability of accurate, on-site measurement of WBGT are all prohibiting factors in the adoption of appropriate policies for all sporting codes played in hot weather conditions.The following recommendations are provided as a means of identifying long and short-term objectives for the sports industry in an endeavour to significantly reduce the risk of dangerous, and sometimes catastrophic incidents occurring as a result of activities conducted in hot weather conditions.

Adoption of Policy for Children All junior sporting clubs and associations or clubs and associations involving junior participants should immediately adopt the stated policy for cancellation or postponement of events involving children that are likely to be played in ambient temperatures equal to or greater than 34 degrees Celsius. All junior sporting clubs or clubs involving junior participants are encouraged to purchase a dry bulb thermometer to measure ambient air temperature on-site to ensure local conditions are accurately measured.

Adoption of Strategies In the absence of accurate methods of measuring WBGT on-site without a suitable device, all sporting clubs and associations should develop or add to their existing policies or rules, the listed 'Strategies for Reducing the Risk of Heat Injury'.

Central Measurement To overcome the current barriers for sporting clubs and associations acquiring WBGT thermometers for the purpose of on-site WBGT measurement, consideration should be given to the proposal of local organisations such as local government authorities purchasing WBGT thermometers with the intention of establishing local climate services. It is recommended that a measured WBGT figure be made available via a regularly updated web page or telephone service to which club or regional association representatives may gain access. This is less accurate than measurements conducted on site, but can provide more accurate figures than those currently available.

Estimated Calculation Formulae are available to estimate the WBGT. Whilst again not as accurate as direct measurement, this strategy does provide substantial guidance to event organisers and officials of the severity of the conditions and the subsequent need to cancel or postpone an activity.
The formula is as follows:
$WBGT = (0.567\ T_{db}) + (0.393\ P_a) + 3.94$
Where T_{db} = dry bulb thermometer temperature and P_a = environmental water pressure (ACSM 1984).
It is recommended in the absence of a WBG thermometer that this method be used to estimate WBGT.

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