Five years of meteorological records were manually tabulated and analyzed for the estimation of the maximum WBGT (an environmental heat stress index) values that could be expected at different times of the day in three regions of Costa Rica. The results were presented at an international conference in the U.S.A. in 1989. The original paper presented at the conference is included, together with improved graphs reproduced from the undergraduate thesis by Mario Fco. Calderón Navarro and Cecilia González Álvarez. This information should help with the planning of long distance running and triathlon events in Costa Rica. Comparison with recent five-year records is encouraged; current, on-site WBGT readings should always be used at endurance events.
Abstract
Increasing popularity of long-distance running has led to a higher incidence of injuries, especially heat-related injuries. The latter can be reduced by scheduling races under appropriate weather conditions. Extreme WBGT values for each month and for the 8:00, 10:00, 12:00 and 14:00 hours, as a useful index of maximum possible environmental heat stress, were calculated for three regions of Costa Rica from 1984 to 1988. The Valle Central region showed WBGT values under 28°C at all times, but only a few 8 o'clock values were under 23°C. The other two regions showed maximal WBGT values exceeding 28°C year round; except for two months at 8:00 hours. It was concluded that long-distance running events should not be scheduled in the Región Atlántica nor in the Pacífico Norte, unless current readings of WBGT showed safe conditions. In Valle Central, it is recommended to take readings of WBGT prior to scheduled events; these events should be programmed for December and January. The earlier hours show the most favorable conditions. Further studies to determine the applicability of the ACSM criteria to tropical countries' runners are suggested.

PROCEDURE
Weather history data were obtained from the National Meteorology Institute, namely, maximum temperatures and their corresponding relative humidity values.

Three different regions of the Country were selected: Valle Central, Región Atlántica, and Pacífico Norte. Maximal monthly temperatures and their corresponding relative humidities were obtained for 8:00, 10:00, 12:00 and 14:00 hours, for a representative weather station from each region, from 1984 to 1988.

Maximal WBGT values were calculated with the formula
WBGT = 0.567 (DBT) + 0.288 (VP) + 3.38 (16)

where DBT (dry bulb temperature) was the maximum monthly temperature and VP (vapor pressure) was calculated from the temperature and its relative humidity, according to the formula:

\[
E + 10^E \cdot \text{LGT} = \log_{10}
\]

\[
L = (7.90298 \cdot ((373.16/T) - 1)) + (5.02808 \cdot \text{LGT} (373.16/T))
+ (1.3816 \cdot (10^4(-7)) \cdot ((10^4(11.344 \cdot (-1(T/375.16))))-1))
+ (8.1328 \cdot (10^3(-3)) \cdot ((10^3(-3.49149 \cdot ((373.16/T)-1))-1))
+ \text{LGT} (373.16)
\]

\[
L = -7.90298X \left( \frac{373.16}{T} \right) - 1 + 5.02808 X \log_{10} \left( \frac{373.16}{T} \right)
- 1.3816 \cdot 10^7 \cdot (10^{11.344} \cdot \left( \frac{T}{373.16} \right) - 1)
+ 8.1328 \cdot 10^3 + 10^{-3.49149} \cdot \left( \frac{373.16}{T} - 1 \right) - 1
+ \log_{10} (373.16)
\]

Smithsonian Meteorological Tables
Smithsonian Institution, 1966 (17)

Five-year average WBGT values were obtained for each month and time of the day.
Results were compared with the ACSM standard mentioned above. Programming was contraindicated during those months and times of the day when extreme WBGT values were equal to or higher than 28°C. On the other hand, programming of long-distance running events was recommended during these months and times of the day when WBGT values were equal to or below 23°C.

RESULTS
Figure #1 shows average WBGT values for Valle Central at 8:00, 10:00, 12:00 and 14:00 hours. At 8 o'clock, maximum WBGT goes from 22.1°C to 24.3°C; at 10 o'clock between 23.9°C and 25.5°C. At noon time ranges from 24.6°C to 26.7°C. Finally, at 2 p.m. stays between 24.6 and 27.2°C.

December and January have the lowest WBGT values, while August and September show the highest.
Values for the Región Atlántica are shown in figure #2. At the earliest time studied, maximum WBGT ranges from 25.6 to 28.3°C; at 10 o'clock from 27.3 to 29.1°C; at 12 noon from 27.9 to 30.0°C, and by the 14:00 hours reaches values between 28.0 and 30.3°C.
For the Región Atlántica, lowest maximal WBGT values are in December, January and February; highest values take place in April and June.
Figure #3 shows maximal WBGT values take for Región del Pacífico Norte. WBGT goes up to 29.0° at 8:00 hours; ranges from 28.4 to 30.3 at 10 o'clock and from 28.7 to 31.2°C at noon. In the afternoon (2 o'clock) values range from 29.0 to 30.8°C.
Months with the lowest maximal WBGT are November, December and January. The highest values happen during April, May and August.
DISCUSSION

First of all, care must be applied in interpreting the preceding data, because the study was conceived as a guideline of maximal possible WBGT values throughout the year. Only when WBGT does not exceed 23°C, scheduling can be safely recommended; at all other times, it will be necessary to obtain current WBGT values, as they may have increased.

Considering this criterion of 23°C, only the Valle Central, in December and January at the 8:00 hours, can be recommended. WBGT values for this region do not exceed 28°C, but adverse conditions are especially likely in June, August and September at the 12:00 and 14:00 hours.

In the Pacífico Norte and Atlántica regions, values get as high as 31.2°C. These are low altitude regions, close to or by the ocean, where environmental heat stress tends to be high.

According to the results, the possibilities for dangerous WBGT values are high; it follows that on-site WBGT readings should be mandatory for long-distance running. Other precautions should be taken such as giving good medical assistance and having enough water available for the runners at reasonable intervals.

Costa Rican runners could be expected to be well acclimated, because of the relatively stable weather conditions year-round. This situation would reduce the risk of heat injuries, although many runners practice at times of the day differing with the race schedules, and many of them are not in optimal conditions for the race, and it is for these runners that the safety guidelines have been devised.

In any case, further study is recommended to investigate the applicability of the ACSM standards to tropical countries runners.

Finally, although rainfall was not considered in this study, Costa Rica has heavy rainfall during a large part of the year, especially during the "warmer" months (18); this is a very important variable to consider for scheduling running events.

SOURCE:
REFERENCES


14. Ibid.


18. Instituto Meteorológico Nacional: op. cit.
Central Valley: *Sabanilla*, 1984-1988

Región Atlántica: Limón, 1984-1988

Pacífico Norte: Guanacaste, 1984-1988