

# Temporal Artery Temperature Measurements Do Not Detect Hyperthermic Marathon Runners

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## ABSTRACT

RONNEBERG, K., W. O. ROBERTS, A. D. MCBEAN, and B. A. CENTER. Temporal Artery Temperature Measurements Do Not Detect Hyperthermic Marathon Runners. *Med. Sci. Sports Exerc.*, Vol. 40, No. 8, pp. 1373–1375, 2008. **Introduction:** Exertional heat stroke is a cause of collapse in marathon runners. Rectal temperature ( $T_{\text{rectal}}$ ) measurement is the usual method of estimating core temperature in collapsed runners, and temporal artery thermometer (TAT) measurement is untested for field use in marathon runners and other athletes. The objective of this study is to compare TAT measurement with  $T_{\text{rectal}}$  measurement in collapsed marathon runners. **Methods:** TAT-500i (Exergen Corp, Wellesley, MA) temperature measurements were obtained using the manufacturer's instruction manual on 60 collapsed marathon runners who had  $T_{\text{rectal}}$  measurements in the finish area medical tent during two consecutive annual races. **Results:** The TAT temperatures identified only 2 of 17 hyperthermic runners ( $T_{\text{rectal}} > 39.4^{\circ}\text{C}$  ( $103^{\circ}\text{F}$ )), a sensitivity of only 0.12, and a Pearson' correlation coefficient of 0.374 ( $r^2 = 0.14$ ). Among the 17 hyperthermic runners, the correlation of  $T_{\text{rectal}}$  to TAT temperatures was 0.526 ( $r^2 = 0.28$ ) with a mean  $\pm$  SD  $T_{\text{rectal}}$  of  $40.7 \pm 0.94^{\circ}\text{C}$  ( $105.1 \pm 1.7^{\circ}\text{F}$ ) and a mean  $\pm$  SD TAT temperature of  $37.4 \pm 1.3^{\circ}\text{C}$  ( $99.4 \pm 2.4^{\circ}\text{F}$ ). Among the 43 collapsed normothermic runners, there was no correlation between the rectal and the TAT measurements ( $r = -0.142$ ,  $P = 0.37$ ). **Conclusions:** These findings indicate that there is little association between the temperatures obtained by temporal artery measurement and  $T_{\text{rectal}}$  measurement in collapsed marathon runners and that TAT temperature is unable to identify hyperthermic runners. Based on these findings, TAT measurement should not be used to assess core body temperature or make treatment decisions for marathon runners with potential exertional heat stroke. **Key Words:** EXERTIONAL HEAT STROKE, HEAT ILLNESS, CORE TEMPERATURE ESTIMATE, HYPERTHERMIA

Core body temperature estimate is a critical vital sign in the assessment of a collapsed marathon runner who may have exertional heat stroke (EHS). The temporal artery temperature transducer, TAT-500i, manufactured by Exergen Co (Boston, MA) and described in a 2005 press release as the thermometer used at the Boston Marathon to estimate core body temperature and to evaluate collapsed marathon runners for possible EHS (<http://www.exergen.com/medical/pressrel/april2005.htm>), was used. There is no peer-reviewed published data to support the use of this apparatus in the field evaluation of athletes during and after exercise. Recent studies of passively heated subjects (6) and hyperthermic

athletes during outdoor exercise in the heat (4) show poor correlation of temporal artery thermometer (TAT) with internal temperatures. Although the use of rectal temperature ( $T_{\text{rectal}}$ ) measurement is inconvenient and uncomfortable for both providers and runners, it is the conventional standard of care and does not miss the diagnosis (2). The core temperature estimate is critical in the decision to actively cool runners with EHS and to prevent the undue morbidity and mortality that can occur with delayed body cooling.

The purpose of this study is to compare the TAT temperature measurements against  $T_{\text{rectal}}$  measurements in collapsed marathon runners who were being evaluated in the finish line medical tent to rule out hyperthermia and possible EHS. This is the first study to examine the validity of this device in hyperthermic athletes requiring medical diagnosis and intervention for EHS in the field.

## MATERIALS AND METHODS

A TAT-5000™ thermometer (Exergen Corp) was purchased to use in the finish area medical tent. The manufacturer's instructions using a modified method for road

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Submitted for publication January 2008.

Accepted for publication February 2008.

0195-9131/08/4008-1373/0

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DOI: 10.1249/MSS.0b013e31816d65bb

aces (swipe from forehead to hairline and then around the back edge of the ear, ending just anterior to the mastoid process) were followed to measure TAT within 1 min of measuring a  $T_{\text{rectal}}$  during the evaluation of collapsed runners for possible EHS.  $T_{\text{rectal}}$  measurements were measured in the medical tent by experienced medical personnel using a digital rectal thermometer (SureTemp 678™, product #01678–200; Welch-Allyn Inc, Skaneateles Falls, NY) during the evaluation of any collapsed runner with possible EHS in two marathon races 1 yr apart. The measurements were recorded prospectively as paired data points to allow for statistical analysis. A waiver for consent was obtained from the IRB because of the noninvasive nature of the TAT-5000 device and it not being reasonable to be able to obtain consent from a critically ill runner.

Statistical analysis was done with SPSS 15.0. The study was evaluated and approved by the Investigational Review Board of the University of Minnesota (#0508M27987).

## RESULTS

Sixty collapsed marathon runners with potential for EHS were evaluated with  $T_{\text{rectal}}$  and TAT measurements in the medical tent during the 2006 and 2007 races. There were 30 paired measurements in each year. The air temperatures during the evaluation of these runners ranged from 20 to 27°C during the first race and from 23 to 30°C during the second race.  $T_{\text{rectal}}$  measurements ranged from 36.1 to 42.2°C (97.0 to 108°F), and 12 of 17  $T_{\text{rectal}}$  measurements 39.4°C or higher were from the warmer year. TAT measurements ranged from 36 to 40.4°C (96.8–104.8°F). The 60 paired temperature sets (see Fig. 1) have a correlation

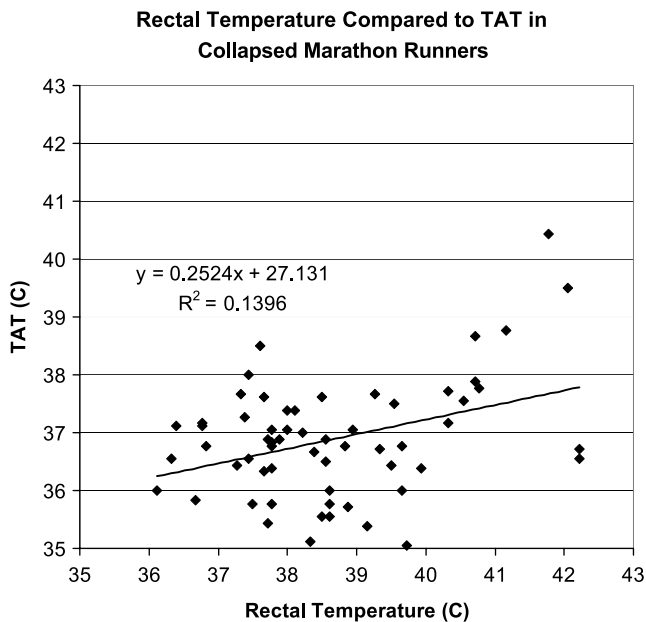


FIGURE 1—Poor correlation between rectal and TAT temperature measurement makes the TAT instrument invalid for field use in athletes.

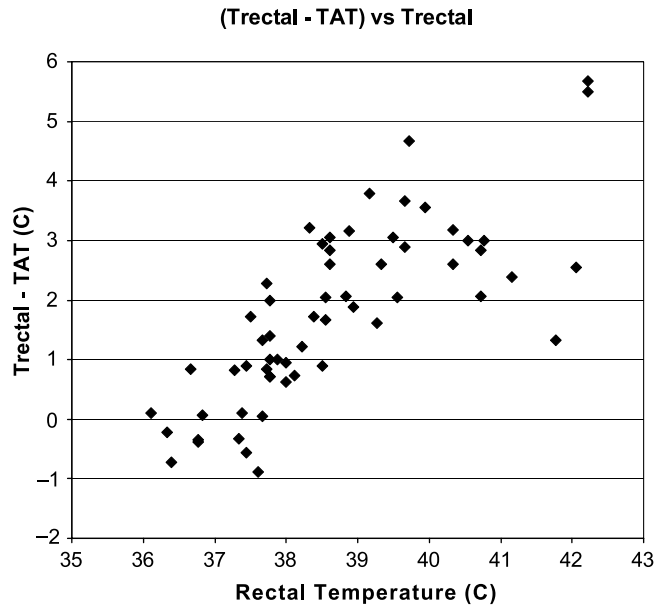


FIGURE 2—Collapsed runners with hyperthermic  $T_{\text{rectal}}$  measurements are missed with TAT temperature measures. The difference between  $T_{\text{rectal}}$  and TAT temperatures should cluster around “0,” and the graph clearly demonstrates that the risk of failing to detect hyperthermia rises as  $T_{\text{rectal}}$  increases into life-threatening range.

coefficient of 0.37 ( $r^2 = 0.14$ ). The differences between  $T_{\text{rectal}}$  and TAT ranged from  $-0.89^{\circ}\text{C}$  ( $-1.6^{\circ}\text{F}$ ) to  $5.7^{\circ}\text{C}$  ( $10.2^{\circ}\text{F}$ ), and in two instances the  $T_{\text{rectal}}$  measured at  $42.2^{\circ}\text{C}$  ( $108.0^{\circ}\text{F}$ ) whereas the TAT temperatures registered at  $36.6^{\circ}\text{C}$  ( $97.8^{\circ}\text{F}$ ) and  $36.7^{\circ}\text{C}$  ( $98.1^{\circ}\text{F}$ ). A full 28% (17 of 60) of readings differed by more than  $2.8^{\circ}\text{C}$  ( $5^{\circ}\text{F}$ ) as shown in Figure 2.

Seventeen collapsed runners were hyperthermic ( $\geq 39.4^{\circ}\text{C}$  [ $103^{\circ}\text{F}$ ] by  $T_{\text{rectal}}$  measurement), and only 2 of these 17 hyperthermic runners were identified by TAT measures, a sensitivity of only 0.12 and a Pearson’s correlation coefficient of 0.374 ( $r^2 = 0.14$ ). There is a distinct difference in the means of the rectal and TAT measurements of the 17 hyperthermic runners with a mean  $T_{\text{rectal}}$  of  $40.7^{\circ}\text{C}$  [SD =  $0.94^{\circ}\text{C}$ ] ( $105.1^{\circ}\text{F}$  [SD =  $1.7^{\circ}\text{F}$ ]) and a mean  $\pm$  SD  $T_{\text{rectal}}$  of  $40.7 \pm 0.94^{\circ}\text{C}$  ( $105.1 \pm 1.7^{\circ}\text{F}$ ) and a mean  $\pm$  SD TAT temperature of  $37.4 \pm 1.3^{\circ}\text{C}$  ( $99.4 \pm 2.4^{\circ}\text{F}$ ). There were nine runners with  $T_{\text{rectal}}$  measurements  $\geq 40.6^{\circ}\text{C}$  ( $105^{\circ}\text{F}$ ), and none of them had TAT measurements above  $40.6^{\circ}\text{C}$  showing very poor temperature discrimination in the highest risk runners (see Fig. 1). The correlation between these 17 paired measures in the hyperthermic runners was minimally higher at  $r = 0.526$  with an  $r^2$  of 0.28. For the 43 normothermic runners ( $T_{\text{rectal}} < 39.4^{\circ}\text{C}$ ), there was actually a negative correlation between the rectal and the TAT temperatures ( $r = -0.142$ ,  $P = 0.37$ ).

## DISCUSSION

$T_{\text{rectal}}$  is an accurate and precise measure of core body temperature after a marathon and is considered the “gold

standard” for field core temperature estimates (2,3). A precise core temperature estimate is critical for proper management of EHS as delays in diagnosis and cooling treatment increase both the area under the cooling curve in degree-minutes and the morbidity and mortality of collapsed runners with EHS (2,7). The TAT thermometer is touted as “the thermometer of the Boston Marathon” and an implied tool for detecting heat stroke in collapsed runners. Although infrared thermometry is an accurate temperature measuring technique and may perform well for detecting fever in indoor clinical settings, it does not precisely estimate core temperature in exercising individuals with exertional hyperthermia and potential heat stroke. Like the tympanic membrane (TM) or aural canal thermometer, it falls short in detecting hyperthermia and is not a valid instrument for field use in athletes (1,4,5). Testing TAT measurements against rectal and esophageal temperature measurements in passively heated subjects and against GI pill thermometry in outdoor exercising athletes showed that TAT readings did not precisely correlate with the core temperature measurements (6,4). Furthermore, skin temperature measurements, and most likely TAT measurements, are influenced by air temperature. The air temperatures during the evaluation of these runners ranged from 20 to 27°C during the first race and from 28 to 29.5°C during the second race, both environments suppressing the TAT to lower than core temperature estimates.

The data from this study demonstrate that core body temperature elevations would not be detected in a timely manner using TAT technology in the field assessment of collapsed athletes to rule out EHS. The correlation coefficient for the entire group of temperature measures (i.e., TAT temperature vs  $T_{\text{rectal}}$ ) was only 0.41, making the TAT useless as a clinical instrument in this population. There was no way to distinguish TAT temperatures that indicate hyperthermic runners as measured by  $T_{\text{rectal}}$ , and conversely, the TAT temperatures did not distinguish normothermic and hyperthermic  $T_{\text{rectal}}$  measurements. The collapsed runners with hyperthermic  $T_{\text{rectal}}$  measurements are missed with TAT measures. In Figure 2, the difference between  $T_{\text{rectal}}$  and TAT temperature plotted against  $T_{\text{rectal}}$  shows the increasing gap in temperature measures as  $T_{\text{rectal}}$  increases into the critical heat stroke range above 40°C. If the TAT measures precisely estimated core temperature, the differences would cluster around “0” on the y axis, again demonstrating little relationship between the measurements and revealing the risk of using TAT temperatures in the field to detect heat stroke in marathon runners. The convenience of the TAT method, while tempting for field use, should not cloud the decision to use the more reliable and time-tested  $T_{\text{rectal}}$  measurements. The TAT thermometer, along with the TM thermometer, is best omitted from the field assessment protocols of collapsed athletes (7). The delays in diagnosis utilizing TAT temperatures could lead to adverse outcomes if this instrument is used in road race settings.

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