Bias and Limits of Agreement between rectal and telemetry pill measurement of core temperature in humans, during intermittent supramaximal exercise while under heat stress.

Paul C. Castle[1], Matt Spencer[2], Nick Webborn[1], and Neil S. Maxwell[1],

[1]Chelsea School Research Centre, University of Brighton, Eastbourne, BN20 7SP, England; [2] Department of Human Movement and Exercise Science, The University of Western Australia, Crawley, Perth, WA 6009, Australia

Measurement of core body temperature using a commercially available telemetry pill (T_{pill}: HTI Ltd, Florida, USA) at rest and during submaximal exercise, in both cold and warm water has been considered valid when compared to rectal thermometry (T_{re})(O'Brien et al. 1998). However, Kolka et al (1993) reported that T_{pill} was quicker to respond to core body temperature changes than T_{re} during exercise at 80% $\dot{V}O_{2peak}$ in a hot environment (29ºC). Discrepancies between both measurement methods have been found, with T_{pill} recording a (mean ±SD) difference of (1.0 ± 0.3ºC) lower than data recorded rectally after 50min submaximal running (Sparling et al. 1993). No published work to date has investigated the validity of T_{pill} measurements during intermittent supramaximal exercise. The purpose of this study was to assess the relationship and level of agreement between T_{pill} and T_{re} during a 40min protocol specific to team sports in both a temperate and a hot, humid environment.

Eight male games players (age, 23.3 ± 2.1 yr; height, 180.5 ± 3.2 cm; body mass, 76.4 ± 6.3 kg; $\dot{V}O_{2peak}$, 3.8 ± 0.4 $L \cdot min^{-1}$; Mean ± SD) participated in the study that was approved by the University of Brighton Ethics Committee. Subjects completed two Cycling Intermittent Sprint Protocols (CISP) that consisted of twenty, 2 min blocks, each including 10 s passive rest, 5 s maximal sprint against a resistance of $75g \cdot kgBM^{-1}$ and 105 s active recovery at 50% of a predetermined $\dot{V}O_{2peak}$. Each CISP was completed in an environmental chamber under a temperate (20 ºC, 40% rh), or a hot, humid (35 ºC, 80% rh) condition in a randomised order. T_{pill} and T_{re} were recorded 1 min into each 2 min block. The reading from the rectal probe was monitored continuously for safety reasons. Results were analysed using Limits of Agreement (Bland and Altman 1986), and a Student's paired sampled t-test, and the Pearson product moment correlation coefficient.

There was a significant relationship ($p<0.01$) between T_{re} and T_{pill} in both temperate ($r = 0.99$), and hot humid environments ($r = 0.95$). The mean difference between T_{re} and T_{pill} for the temperate and hot, humid environments were (0.2 ± 0.3 ºC) and (0.1 ± 0.4 ºC), respectively. For both temperate and hot and humid conditions several data points were above and below the statistical limits of agreement (i.e. the mean difference between two measures ± 2SD). For the temperate condition T_{pill} underestimated T_{re} by 0.8 ºC and overestimated by 0.4 ºC. This was exacerbated during the hot, humid environment, with T_{pill} underestimating T_{re} by 0.9 ºC and overestimating by 0.7 ºC. The differences in rate of change of temperature detected by T_{pill} and T_{re} were not significant for either the temperate ($p=0.74$) or hot, humid environment ($p=0.26$).

The results of the present study indicate that although T_{re} and T_{pill} are significantly correlated, the limits of agreement between both methods were not statistically acceptable. However, the level of acceptance should be ascertained prior to performing Bland and Altman's (1986) limits of agreement, for ±2SD equates to a range of 1.6 ºC. This range would not be clinically acceptable and may lead to the misdiagnosis of heat injury.

Bland. J. M. & Altman, D, G, (1986). *The Lancet.* **1,** 307-310.,
Kolka, M. A., Quigley, M. D., Blanchard, L. A., Toyota, D. A., and Stephenson, L. A. (1993). *J. thermal. Biol,.* **18 (4),** 203-210.
O'Brien, C., Hoyt, R. W., Buller, M. J., Castellani, J. W., and Young, A. J. (1998). *Med. Sci. Sports Exerc.,* **30 (3),** 468-472.
Sparling, P. B., Snow, T. K., and Millard-Stafford, M. L. (1993). *Aviat. Space Environ. Med.* **64,** 760-763.