VALIDATING FIELDABLE INDICES OF CORE TEMPERATURE

W.S. Roberts, J.D. Cotter, D. Amos and W.M. Lau, Combatant Protection and Nutrition Branch, Defence Science and Technology Organisation, Melbourne, Australia.

Standard methods of core temperature (T_c) measurement, in the oesophagus (T_{es}) or rectum (T_{re}), are poorly suited to athletic, occupational or military application, hence the desire for development of less obtrusive indices. Gastro-intestinal radio-pill (T_{gi}), infra-red tympanic (T_{ty}) and insulated skin (T_{inskin}) temperatures may provide a solution but are not faultless. The measurement of T_{gi} is expensive and incurs problems with sequential application. T_{ty} is readily contaminated by ambient temperature if methodology is inadequate. T_{inskin} shows some promise as a surrogate index of T_c (Taylor, et al., 1998), but has not been fully validated. We examined the accuracy of T_{inskin} as a surrogate measure of T_c in military applications - including periods of rising, falling and static T_c, under various environmental conditions. Subjects were thirteen heat-acclimatised, euhydrated, healthy volunteers from the Australian Army (mean±SD: age = 25±5 y; height = 173±11 cm; mass = 74±12 kg). Following two familiarisation sessions, subjects participated in experimental sessions with various environmental conditions; Wet-Bulb Globe Temperature (WBGT) = 21.2°C (Dry Bulb (DB)=25°C), 25.9°C (DB=30°C), 29.7°C (DB=40°C) and/or 32.2°C (DB=35°C). Each session was conducted at least one week apart and consisted of 15-min seated rest (REST), 45-min treadmill walking (5-6 kph at 5-10% grad; WALK1), 15-min manual load handling (repeatedly lifting and carrying a 20-kg crate; LOAD), a second walk, of up to 60 min (5-7 kph at 0-10% grad; WALK2) and 20-min seated recovery (RECOV). Subjects wore standard army combat uniform and carried a 20-kg pack during walk phases. T_c was measured at 1-min intervals from T_{re}, T_{es}, T_{gi} and T_{inskin} (positioned over spine at T2-T4), and from T_{ty} at 15-min intervals. T_{inskin} showed a stronger association with T_{es} (r=0.68, n=3424, p<0.01) than with T_{re} (r=0.64, n=3957, p<0.01), independently of environmental condition. When separated by environmental condition the associations become stronger with increasing heat stress. For example, the relationship between T_{es} and T_{inskin} improved with greater heat stress (WBGT: 21.2°C, r=0.42; 25.9°C, r=0.65; 29.7°C, r=0.78; 32.2°C, r=0.80). When separated by exercise phase, T_{inskin} predicted T_c poorly during REST (eg. T_{es}: WBGT 32.2°C, r=0.04, n=136, p>0.05, *SEE*=0.13) and LOAD carriage (eg. T_{es}: WBGT 32.2°C, r=0.4, n=113, p<0.01, *SEE*=0.37), even under increased heat stress. However during WALK1, WALK2 and RECOV, T_{es} and T_{inskin} associations ranged from moderate to strong: r=0.67, n=382, p<0.01; r=0.56, n=107, p<0.01; r=0.86, n=127, p<0.01, respectively, depending on phase. T_{gi} had a stronger association with T_{re} (r=0.92, n=3198, p<0.01; $T_{re} = 0.922T_{gi} + 2.84$, *SEE*=0.25) than with T_{es} (r=0.83, n=2652, p<0.01; $T_{es} = 0.746T_{gi} + 9.19$, *SEE*=0.34), whereas T_{ty} tended to be a poorer predictor of both T_{re} (r=0.69, n=334, p<0.01; $T_{re} = 0.47T_{ty} + 20.0$, *SEE*=0.49) and T_{es} (r=0.77, n=310, p<0.01; $T_{es} = 0.47T_{ty} + 19.5$, *SEE*=0.39). In summary, T_{inskin} represented T_{es} with more confidence than T_{re}. The relationship between T_{inskin} and T_cs improved with increasing heat stress. Exercise phases where T_c remains relatively constant displayed an uncoupling of T_{inskin} and T_cs, whereas epochs with increasing or decreasing T_c produce moderate to strong T_c to T_{inskin} dependence. T_{gi} by radio-pill thermometry generally had a stronger association with standard measures of T_c than did T_{ty} by infra-red thermometry.

Taylor, N.A.S., Wilsmore, B.R., Amos, D., Takken, T. & Komen, T. (1998) Insulated skin temperatures: Indirect indices of human body-core temperature. DSTO-TR-0752. Melb.

warren.roberts@dsto.defence.gov.au