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FRONT MATTER: COMMENT

How should we measure occupational heat stress?

Comment on: Jay O, Brotherhood JR. Occupational heat stress in Australian workplaces. Temperature 2016; 3:394-411; http://dx.doi.org/10.1080/23328940.2016.1216256

More than forty years ago a wise American industrial engineer, Theodore F. Hatch, wrote "The use of a single index value of heat stress in the past (ET, for example), undoubtedly delayed progress in the development and application of proper controls, such as radiation shielding, in many industrial establishments. We do not want to return to that era of limited insight into the needs for control of industrial heat exposures." (ref. 1, page 373).

Return to it? We have not yet *left* that era of limited insight. Industry and sport are still dominated by a single index, the Wet-bulb Globe Temperature (WBGT) (an approximation to Effective Temperature (ET)), whereas the six primary components of heat stress – air temperature, mean radiant temperature, absolute humidity, air velocity, and the workers' clothing and activity – are rarely reported. The omission is serious. Indexes reflect the *intensity* of heat stress, from which we try to predict its likely effect on human health, comfort, and performance. But the primary components identify the *causes* of heat stress, and they tell us how to control it.[1,2]

Throughout their review of occupational heat stress in Australian workplaces, Jay and Brotherhood[3] rightly emphasize the need to measure the primary components, and they devote considerable space to explaining the biophysical mechanisms through which each component contributes to human heat exchanges and hence body temperature. These measurements are doubly important because WBGT itself is deeply flawed – by its underestimation of the stress of restricted evaporation, and by measurement errors associated with the use of non-standard instrumentation and unsatisfactory calibration procedures.[4]

By contrast, the routine measurement[1] of the six primary components – which can easily be done by a single observer, using simple and inexpensive instruments – yields more accurate and comprehensive heat-stress indexes than WBGT, such as the Predicted four-hour Sweat Rate (P4SR) and the Belding-Hatch Index (BHI) (ref. 1, pages 372–373, and ref. 5, pages 121–122). The measurements also yield estimates of heat exchange that can be of great practical value – as when they showed that the metabolic heat load of men suppressing Australian summer bushfires with hand tools was more than twice the combined heat load from the fire and the weather (ref. 5, pages 126–128). This finding showed, contrary to popular belief, that the main task for bushfire fighters' clothing is not to *keep* heat out but to *let* it out – a crucial requirement in providing suitable clothing.

After identifying 89 publications in a literature search, Jay and Brotherhood analyzed the 29 that met more stringent selection criteria such as peer review, at least some components of the thermal environment, and the workers' deep body ('core') temperature or sweat rate. Sport-related occupations were excluded.

The review pays special attention to the mining, agricultural, and construction industries, whose activities mainly take place in the hotter and sometimes more humid parts of Australia, and to the military and emergency services, which often experience heat stress because of strenuous work and protective clothing. It presents the results in four tables, using a standard layout that simplifies the task of cross-referencing between them. For each of the above five occupations, and as many as 15 specific activities within each one, the tables show the results (or the lack thereof) for every component of heat stress, together with WBGT and the workers' physiological and subjective responses.

The main findings of the review are that in most industries core temperatures were low, less than 38.0°C, because of light work or self pacing, even when air and mean radiant temperatures were high. The highest core temperatures, rarely more than 39.6°C, occurred in occupations – military and emergency services, and deep underground mining – that combined strenuous work with limited opportunity for self pacing. Sweat loss was generally less than 1 l/h, and dehydration less than 3.0% of body mass. The authors conclude that "Despite being a hot country, occupational heat stress is relatively mild for most industries assessed, by virtue of the self-regulated pacing of work possible in most jobs."

Inevitably, there are gaps in the tables. WBGT was reported in 95% of the 29 studies examined, but air velocity, radiant heat, and clothing were reported in, respectively, only 55%, 24% and 24% of them. Even with these flaws, it is still useful to have available such a systematic, comprehensive, and convenient tabulation of what was, and was not, reported in each study. It might even encourage more complete measurement in future studies!

Among the measurements frequently omitted, Jay and Brotherhood emphasize the critical importance of low air velocity in hot and humid conditions, exemplified by Donoghue et al.'s finding (reference in Jay and Brotherhood[3]) that the incidence of heat exhaustion in a hot underground mine increased steeply as air velocity fell below 1.6 m/s – a finding that provided a secure basis for subsequent control measures.

Jay and Brotherhood draw attention to several gaps in current knowledge of occupational heat stress – notably in forestry, and in agricultural work such as fruit picking and grape harvesting. Moreover, they note an almost complete lack of information for women, and they recommend that this omission be urgently addressed.

This important review not only summarizes present knowledge of occupational heat stress in Australia, it makes a powerful case for a more rational approach, based on the routine measurement of all 6 primary components, to its assessment and control.

References

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