CLIMATE CHANGE AND OCCUPATIONAL HEAT STRESS

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INTRODUCTION

During recent years increasing attention has been paid to the health impacts of global climate change. Global climate change primarily means that the average global temperature increases 1.8-4.0 °C (average increase 3.0 °C) until 2100 (IPCC, 2007) depending on actions to limit greenhouse gas emissions. Increasing temperature means more occupational exposure to heat.

OCCUPATIONAL HEAT EXPOSURE GUIDELINES AND STANDARDS

To protect workers from the effects of heat exposure various heat stress indices, guidelines and standards have been developed. The most commonly used is the Wet Bulb Globe Temperature (WBGT) index developed by the US Army many decades ago (Ramsey and Bernard, 2000). This index takes into account air temperature, radiant temperature, humidity and air movement and is the basis for time limitations of work at different metabolic rates (Figure 1).

The figure shows the basic principle used in all heat guidelines: work intensity or the work/rest time ratio has to be reduced as the heat exposure increases in order to protect the worker. The NIOSH recommendations (NIOSH, 1986) were followed by a standard from the International Standards Organization (ISO, 1989), which had omitted the “ceiling limit” (all work to be stopped) and was made less restrictive at the lower metabolic heat levels. Whichever assessment of the WBGT values is used, it is striking how narrow the WBGT range is between the heat exposure level that is acceptable for continuous workplace exposure (e.g. 26 ºC at 250 W/m²; Figure 1) and a work/rest time ratio of 15 min/hour (31 ºC at 250 W/m²; Figure 1).

The WBGT is an empirical index and does not account for all climate factors in a physically correct way. It also applies only to workers in cotton shirt and trousers. More advanced indices are based on the human heat balance equation and applies generally to all kinds of exposures (Malchaire et al, 1999, 2000). One such index is the Predicted Heat Strain Index (PHS) (Malchaire et al., 2001) that now replaces Required Sweat rate as International standard (ISO 7933, 2002).
Figure 1. Recommended heat exposure limits (active work time during an exposure hour) for an acclimatized worker at different WBGT levels and metabolic heat levels (work intensity) (modified from ISO 7243).

CLIMATE CHANGE WILL INCREASE HEAT STRESS IN MANY COUNTRIES

The areas around the planet that are expected to get the highest temperature increases due to global climate change are mainly inland areas within the large continents with an increase of 1-3 °C until 2020 and 3-5 °C until 2080 (IPCC, 2007). In these areas the maximum temperatures during the hottest part of the year are already close to 40 °C and increasing over time (documented by Kjellstrom and Lemke, to be published). An additional 3-5 °C will make heavy work (e.g. in agriculture and construction work) very difficult during the hottest periods.

A formula developed by the Australian Bureau of Meteorology (ABOM, 2007) makes it possible to calculate approximately the WBGT for typical outdoor work exposure situations with calm air movements. It includes air temperature and humidity and makes assumptions of radiated heat. We used this formula with daily data for Delhi (Figure 2) and found that during the hotter months (May to August) the average WBGT during daylight hours constantly exceeds 30 °C, and often exceeds 35 °C. Such high WBGT levels are signs of extreme heat stress (Figure 1).

Additional calculations of PHS for such extreme climatic condition predict increases in rectal temperature beyond 38 °C. This is the level that is recommended in both ISO 7243 and ISO 7933 not to be exceeded in average in the exposed population. In addition the calculated sweat rates approaches 1 to 1.5 l/h ending up in an accumulated water loss of up to 10 during an 8 hour shift.
Modelling by the Intergovernmental Panel on Climate Change (IPCC, 2007) forecasts substantial increases of future annual average temperatures (and in many places also increases of humidity) in areas populated by billions of people, and it is likely that for many workers the WBGT index levels will also increase. The eventual occupational impacts of such increasing heat exposure are dependent on clothing, radiated heat and workplace wind speed, but it is most likely that global climate change is a threat to safe, comfortable and productive thermal working environments for a significant part of the global population.

OCCUPATIONAL HEAT STRESS AND WORKER PRODUCTIVITY

Heat affects human behavior and performance in many ways (Ramsey, 1995). The relationship between occupational heat exposure and productivity was pointed out already in 1974 by Axelsson (1974) and was further commented upon by Holmer (1996), but very little research has been carried out aiming at quantifying this relationship in work situations where workers are “self-paced” (the slowing down of work as a defense mechanism in severe heat exposure is labeled “autonomous adaptation” by climate change researchers). Productivity has also been analyzed for indoor climates in relation to air conditioning needs (Parsons, 2003). The first report on this issue in the context of global climate change (Kjellstrom, 2000) likened the heat effect on work output to the “disability” caused by defined diseases, and concluded that this effect may contribute to disability in a population to a greater degree than most diseases.

This impact of human function and health is the “forgotten” effect of global climate change. It will be of particular importance in tropical developing countries where climate change during this century will be most prominent. It is likely to have a significant impact on the productivity of many workers, unless effective adaptive measures reducing the occupational heat stress are implemented. This may be practically and economically possible for indoor environments, but is much more difficult, if not impossible, for outdoor environments. The eventual result is that it will be more difficult to achieve economic and social development in the affected countries.
REFERENCES

Kjellstrom T (2000) Climate change, heat exposure and labour productivity. Epidemiology, 11, S144/