Supplementary Material

Greater risk of thermal strain in the late afternoon than morning during exercise in the gym without airflow and air conditioning on a clear summer day

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**METHODS**

**Calculations**

***Physiological variables***

Mean skin temperature (Tsk) was calculated as follows (Ramanathan 1964):

(Eq. 1): Tsk = 0.3·Tch + 0.3·Tup + 0.2·Tth + 0.2·Tca [ºC]

where Tch is chest skin temperature, Tup is upper arm skin temperature, Tth is thigh skin temperature and Tca is calf skin temperature.

Total sweat loss was calculated as follows:

(Eq. 2): Total sweat loss = body mass loss + the volume of water ingested [L].

Age-predicted maximal HR (HRmax) was calculated by subtracting the age from 220.

Heat storage (S) was calculated as the following heat balance model:

(Eq. 3): S = (M – W) ± R ± C ± K − Esk − (Cres + Eres) [W·m−2]

where (M – W) is metabolic heat production, M is metabolic rate, W is external work, R is heat exchange by radiation, C is heat exchange by convection, K is heat exchange by conduction, Esk is heat loss by evaporation from the skin, and (Cres + Eres) is respiratory heat loss by convection and evaporation, respectively (all units in W·m−2). With R, C and K, positive (+) and negative (−) values are heat gain and loss, respectively. In general, heat exchange by conduction (K) is assumed to be negligible.

Metabolic heat production (M – W) was calculated as M minus W. Metabolic rate (M) was calculated as follows (Keytel et al. 2005):

(Eq. 4): M = [−55.0969 + (0.6309·HR) + (0.1988·body mass) + (0.2017·age)]/4.184·60·Th [W·m−2]

where HR is an individual’s average HR during the sessions in bpm (153±8 bpm in AM trial and 155±10 bpm in PM trial), body mass is an individual’s pre-exercise body mass in kg, age is an individual’s age in years and Th is the exercise duration in hour. External work (W) was calculated as follows (ASHRAE 2005):

(Eq. 5): W = µ·M [W·m−2]

where µ is the body’s mechanical efficiency (10% in the present study because of assuming 8-10% for running [Nishi 1981]).

In an outdoor environment under the sun, heat exchange by radiation (R) was calculated as follows (Błażejczyk and Matzarakis 2007):

(Eq. 6): R = Q + L [W·m−2]

where Q is absorbed short-wave radiation and L is net long-wave radiation (both units in W·m−2).

Absorbed short-wave radiation (Q) was calculated as follows (Błażejczyk 2004):

(Eq. 7): Q = (0.0014·Kg2 + 0.476·Kg − 3.8)·(1 − 0.01·*ac*)·Irc [W·m−2]

where Kg is global solar radiation in W·m−2, *ac* is albedo of clothing in % (assumed to be 57% for light-coloured clothing [Kenny et al. 2008]) and Irc is coefficient reducing convective and radiative heat transfer through clothing (using the equation below). Coefficient reducing convective and radiative heat transfer through clothing (Irc) was calculated as follows (Błażejczyk 2004; Błażejczyk and Matzarakis 2007):

(Eq. 8): Irc = hcl/(hcl + hcr + 21.55·10−8·Tk3)

where hcl is coefficient of heat transfer through clothing in W·(m2·K)−1 (using the equation below), hcr is coefficient of convective and radiative heat transfer in W·(m2·K)−1 (using the equation below) and Tk in ambient temperature in K. Coefficient of heat transfer through clothing (hcl) was calculated as follows (Błażejczyk 2004; Błażejczyk and Matzarakis 2007):

(Eq. 9): hcl = (0.013·*ap* − 0.04·Ta − 0.503)·0.53/{Rcl·[1 − 0.27·(*v* + *mv*)0.4]} [W·(m2·K)−1]

where *ap* is air pressure in hPa, Ta is ambient temperature in °C, Rcl is the intrinsic clothing insulation in clo (0.405 in this study, using the equation below), *v* is wind speed in m·s−1 and *mv* is an individual’s average moving velocity during the sessions in m·s−1 (1.5 in this study; Suda et al. 2004). Coefficient of convective and radiative heat transfer (hcr) was calculated as follows (Błażejczyk 2004; Błażejczyk and Matzarakis 2007):

(Eq. 10): hcr = (0.013·*ap* − 0.04·Ta − 0.503)·(*v* + *mv*)0.4 [W·(m2·K)−1].

Net long-wave radiation (L) was calculated as follows (Błażejczyk 2004; Błażejczyk and Matzarakis 2007):

(Eq. 11): L = (0.5·Lg + 0.5·La − Ls)·Irc [W·m−2]

where Lg is the balance for heat exchange by thermal radiation between human body and the ground in W·m−2 (using the equation below) and La and Ls are the balance for heat exchange by thermal radiation between the atmosphere (La) and human body (Ls) in W·m−2 (using the equation below). The balance for heat exchange by thermal radiation between human body and the ground (Lg) was calculated as follows (Błażejczyk and Matzarakis 2007):

(Eq. 12): Lg = ɛ·*σ*·(273+Tgr)4 [W·m−2]

where ɛ is the area weighted emissivity coefficient for natural objects (0.97 in the present study), *σ* is the Stefan-Boltzmann constant, 5.67·10−8 in W·(m2·K4)−1 and Tgr is average floor surface temperature during the sessions in °C (29°C in AM trial and 30°C in PM trial). The balance for heat exchange by thermal radiation between the atmosphere (La) and human body (Ls) were calculated as follows (Błażejczyk and Matzarakis 2007):

(Eq. 13): La = ɛ·*σ*·(273 + Ta)4·[0.82 − 0.25·10(−0.094·*vp*)] [W·m−2]

where *vp* is vapour pressure in hPa.

(Eq. 14): Ls = ɛh·*σ*·(273 + Tsk)4 [W·m−2]

where ɛh is the area weighted emissivity coefficient for human body (0.95 in the present study) and Tsk is an individual’s average mean skin temperature during the sessions in °C (34.7±0.6°C in AM trial and 35±0.4°C in PM trial).

Heat exchange by convection (C) was calculated as follows (Błażejczyk and Matzarakis 2007):

(Eq. 15): C = hcr·(Ta − Tsk)·Irc [W·m−2].

Heat loss by convection and evaporation from respiration (Cres + Eres) was calculated as follows (ASHRAE 2005):

(Eq. 16): Cres + Eres = 0.0014·M·(34 − Ta) + 0.0173·M·(5.87 − Pa) [W·m−2]

where Pa is the water vapour pressure in the ambient air in kPa (using the equations below). The water vapour pressure in the ambient air (Pa) was calculated as follows (Parsons 2014):

(Eq. 17): Pa = Psa·RH [kPa]

where Psa is the saturated water vapour pressure in kPa (using the equations below) and RH is relative humidity. The saturated water vapour pressure (Psa) was calculated as follows (Parsons 2014):

(Eq. 18): Psa = 0.1·exp[18.956 − 4030.18/(T + 235)] [kPa]

where T is a temperature in °C.

Heat loss by evaporation from the skin (Esk) was calculated as follows (Parsons 2014):

(Eq. 19): Esk = [*w*·(Psk,s − Pa)]/[Re,cl + (1/*f*cl·he)] [W·m−2]

where *w* is skin wettedness (assumed to be 0.95 for fully acclimated individuals [Ravanelli et al. 2018]), Psk,s is the partial water vapour pressure at the skin in kPa (assumed to be the saturated water vapour pressure [Psa] at Tsk), Re,cl is the evaporative resistance of clothing in (m2·kPa)·W−1 (0.01 in both trials), *f*cl is the clothing area factor (1.12 in both trials) and he is evaporative heat transfer coefficient (using the equations below). Evaporative heat transfer coefficient (he) was calculated as follows (Parsons 2014):

(Eq. 20): he = 16.5·hc [W·(m2·kPa)−1]

where hc is convective heat transfer coefficient (using the equations below). Convective heat transfer coefficient (hc) was calculated as follows (Parsons 2014):

(Eq. 21): hc = 8.3·*v*0.6 [W·(m2·kPa)−1].

***Environmental variables***

Absolute humidity was calculated as follows (Parsons 2014):

(Eq. 22): Absolute humidity = 2.17·Pa/Tk [kg·m−3].

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