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## Research Letter | Environmental Health

# Thermal and Perceptual Responses of Older Adults With Fan Use in Heat Extremes A Secondary Analysis of a Randomized Clinical Trial

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## Introduction

The US Centers for Disease Control and Prevention (CDC) advise against fan use above 32 °C (ie, 90 °F) because it can increase body temperature.<sup>1</sup> Modeling suggests fans reduce body temperature up to 37 to 39 °C (ie, 99 to 102 °F), depending upon humidity.<sup>2</sup> In humid heat, fan use reduced body temperature in young adults at 42 °C (ie, 108 °F),<sup>3</sup> or healthy older adults at 36 °C (ie, 97 °F).<sup>4</sup> Above 36 °C, fan use effects on older adults remain unclear but is likely detrimental at 42 °C or hotter.<sup>5</sup> We reported that fan use with and without skin wetting reduces cardiac strain of older adults in hot and humid heat but tripled cardiac strain in very hot and dry heat.<sup>6</sup> Here, we report the results for body temperature, sweating, and thermal perceptions.

## Methods

This secondary analysis of a crossover trial was approved by the University of Sydney and Montreal Heart Institute ethics committees (eMethods in [Supplement 1](#)). Reporting follows [CONSORT](#) reporting guideline, and written consent was provided (eMethods in [Supplement 1](#)). The trial protocol can be found in [Supplement 2](#). Participants without or with coronary artery disease (CAD) underwent 3-hour exposures to hot and humid (38 °C [ie, 100 °F]; 60% humidity) or very hot and dry (45 °C [ie, 113 °F]; 15% humidity) heat. In hot and humid heat, all participants underwent 4 exposures separated by 72 hours or more, in randomized sequence: control, fan use, skin wetting, and fan use with skin wetting. In very hot and dry heat, participants with CAD only underwent control and skin wetting exposures. The prespecified secondary outcomes were the change in rectal temperature (self-inserted thermistor), sweat rate (weight change), as well as the change in thermal sensation and comfort that were measured using a 7-point and 4-point scale, respectively (ASHRAE Standard 55; reported as arbitrary units [AU]).

Outcomes were analyzed using restricted maximum likelihood-based repeated measures including a term for exposure. The covariance structure yielding the smallest Akaike information criterion, between the unstructured and compound symmetry covariance structures, was used to model within-participant errors. Statistical significance was set at  $P < .05$ , and results are presented with 95% CIs. SAS version 9.4 (SAS for Statistical Computing).

## Results

Fifty-eight participants (31 without CAD [53%] and 27 with CAD [47%], 39 males [67%], 19 females [33%], mean [SD] age, 68 [7] years; mean [SD] height, 1.71 [0.09] m; mean [SD] weight, 79 [15] kg) underwent a total of 320 exposures that were included in the analyses (eFigure in [Supplement 1](#)). In hot and humid heat (**Figure 1**), rectal temperature was reduced by fan use (−0.1 [95% CI, −0.1 to 0] °C;  $P = .02$ ), but not skin wetting alone (0 [95% CI, −0.1 to 0.1] °C;  $P = .73$ ) or combined with fan use (0 [95% CI, −0.1 to 0.1] °C;  $P = .67$ ). Sweating was greater with fan use (57 [95% CI, 39 to 75] mL/h;

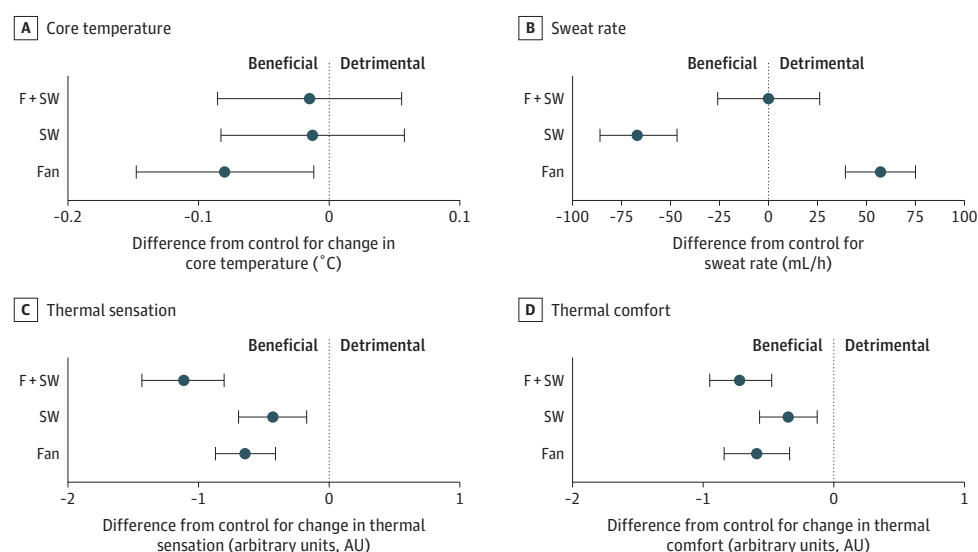
## + Supplemental content

Author affiliations and article information are listed at the end of this article.

$P < .001$ ), reduced by skin wetting ( $-67$  [95% CI,  $-86$  to  $-47$ ] mL/h;  $P < .001$ ), and unaffected by fan use with skin wetting ( $0$  mL/h [95% CI,  $-26$  to  $26$ ] mL/h;  $P = .99$ ). Thermal sensation and comfort improved with fan use ( $-0.6$  [ $-0.9$  to  $-0.4$ ] AU;  $P < .001$ ;  $-0.6$  [95% CI,  $-0.8$  to  $-0.3$ ] AU;  $P < .001$ ), skin wetting ( $-0.4$  [95% CI,  $-0.6$  to  $-0.1$ ] AU;  $P = .002$ ;  $-0.4$  AU [95% CI,  $-0.6$  to  $-0.1$ ] AU;  $P = .002$ ), and fan use with skin wetting ( $-1.1$  [95% CI,  $-1.4$  to  $-0.8$ ] AU;  $P < .001$ ;  $-0.7$  95% CI,  $[-1.0$  to  $-0.5]$  AU;  $P < .001$ ).

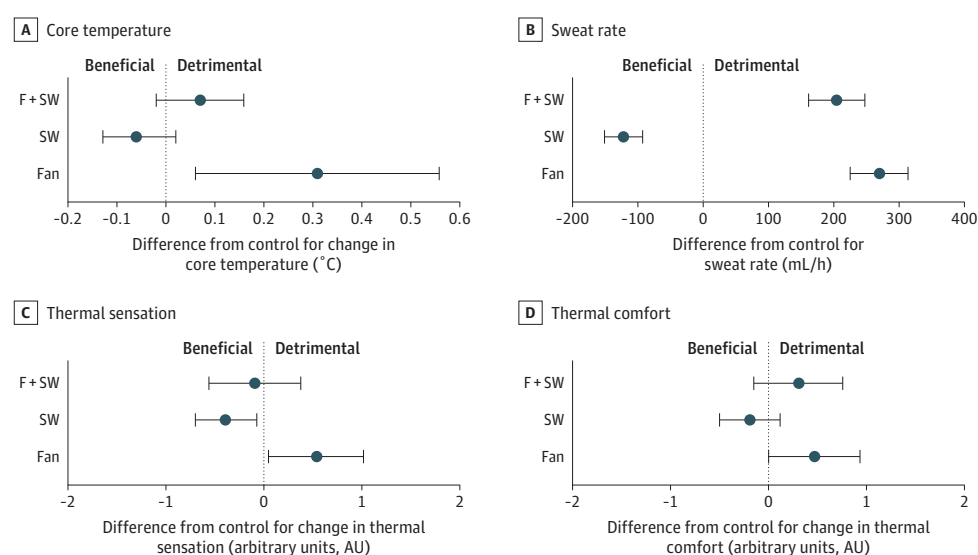
In very hot and dry heat (**Figure 2**), rectal temperature was worsened by fan use ( $0.3$  [95% CI,  $0.1$  to  $0.6$ ] °C;  $P = .02$ ), but not skin wetting alone ( $-0.1$  [95% CI,  $-0.1$  to  $0$ ] °C;  $P = .13$ ) or combined with fan use ( $0.1$  [95% CI,  $0$  to  $0.2$ ] °C;  $P = .11$ ). Sweating was greater with fan use alone ( $270$  [95% CI,  $226$  to  $314$ ] mL/h;  $P < .001$ ) and combined with skin wetting ( $205$  [162 to  $248$ ] mL/h;  $P < .001$ ), but

Figure 1. Study Outcomes During Exposure to Hot and Humid Heat (38 °C, 60% Relative Humidity)



F + SW indicates exposures with combined fan use and skin wetting; Fan, exposures with fan use; SW, exposures with skin wetting.

Figure 2. Study Outcomes During Exposure to Very Hot and Dry Heat (45 °C, 15% Relative Humidity)



F+SW indicates exposures with combined fan use and skin wetting; FAN, exposures with fan use; SW, exposures with skin wetting.

reduced by skin wetting ( $-121$  [95% CI,  $-150$  to  $-92$ ] mL/h;  $P < .001$ ). Fan use worsened thermal sensation ( $0.5$  [95% CI,  $0.1$  to  $1.0$ ] AU;  $P = .03$ ) and discomfort ( $0.5$  [95% CI,  $0$  to  $0.9$ ] AU;  $P = .047$ ). Skin wetting improved thermal sensation ( $-0.4$  [95% CI,  $-0.7$  to  $-0.1$ ] AU;  $P = .02$ ), but not comfort ( $-0.2$  [95% CI,  $-0.5$  to  $0.1$ ] AU;  $P = .23$ ). Fan use with skin wetting did not affect thermal sensation ( $-0.1$  [95% CI,  $-0.6$  to  $0.4$ ] AU;  $P = .69$ ) and comfort ( $0.3$  [95% CI,  $-0.1$  to  $0.8$ ] AU;  $P = .18$ ).

## Discussion

Contrary to CDC advice,<sup>1</sup> this study found that fan use at  $38^{\circ}\text{C}$  (ie,  $100^{\circ}\text{F}$ ), 60% humidity did not increase body temperature in older adults with and without CAD. Rather, fan use marginally decreased body temperature and improved perceptions. In very hot and dry heat, fan use worsened all outcomes and should be discouraged for these conditions. Skin wetting reduced sweating and improved perceptions in both heat conditions and could be recommended to minimize dehydration risk. Limitations include the short, laboratory-based exposures. Replication of these results in other heat-vulnerable populations should be considered.

## ARTICLE INFORMATION

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**Author Contributions:** Drs Gagnon and Jay had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Concept and design:** Chaseling, Hospers, Graham, Capon, Crandall, Fiatarone Singh, Gagnon, Jay.

**Acquisition, analysis, or interpretation of data:** Chaseling, Vargas, Hospers, Barry, Harwood, Bartlett, Debray, Lynch, Crandall, Mavros, Bi, Nigam, Chabot-Blanchet, Gagnon, Jay.

**Drafting of the manuscript:** Chaseling, Harwood, Lynch, Gagnon, Jay.

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**Supervision:** Chaseling, Vargas, Fiatarone Singh, Gagnon, Jay.

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**Data Sharing Statement:** See [Supplement 3](#).

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## SUPPLEMENT 1.

### eMethods.

**eFigure.** Participant Flowchart Through the Study Protocol

### eReferences.

## SUPPLEMENT 2.

### Trial Protocol

## SUPPLEMENT 3.

### Data Sharing Statement