



Links Between Physiological and Perceptual Strain in Uncompensable Heat Stress

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Introduction

- Environmental heat challenges heat balance and results in heat strain for body systems.
- Heat strain indices have been developed as holistic tools to determine risk level for physiological and perceptual strain during various activities across a range of heat stress.¹⁻⁴
- The physiological strain index (PhSI) has been widely used to track thermoregulatory and cardiovascular strain.⁴
- Physiological measures may be unsuitable for some extreme settings (e.g., firefighting, military operations).⁵
- **The current study aimed to explore the potential of perceptual measures for evaluating physiological strain during exposure to uncompensable heat stress.**

Methods

- Ten healthy, physically active, and non-heat-acclimated males (age: 29 ± 7 y; height: 1.79 ± 0.11 m; body mass: 77.4 ± 9.3 kg; $\dot{V}O_{2peak}$: 51.9 ± 5.3 mL/kg/min) performed two randomized, crossover, matched exercise trials (60min cycling at $\sim 55\% \dot{V}O_{2peak}$) in hot-dry (HD) and warm-humid (WH) conditions with equivalent wet-bulb globe temperature (WBGT).
- Rectal temperature, skin temperature, heart rate, rating of perceived exertion (RPE), and thermal sensation were measured at multiple timepoints during trials.
- PhSI and perceptual strain index (PeSI) were calculated using validated equations.^{1,4}
- Multiple statistical analyses were employed to evaluate the relationship between PhSI and PeSI, with significance set as $p \leq .05$.

Results

- A moderate-to-strong correlation was observed between the PeSI and PhSI in the HD ($r = .782, p < .001$) and WH ($r = .899, p < .001$) conditions.
- PeSI significantly predicted PhSI in both HD and WH conditions (both $p < .001$ from Fisher's Exact Test). The areas under the ROC curves were 0.858 (95% CI: 0.756–0.960) for HD and 0.947 (95% CI: 0.890–0.999) for the WH condition using a PhSI cutoff of 7.
- Higher levels of perceived strain (PeSI) were associated with increased physiological strain (PhSI) ($\beta = 1.33, p < .001$).

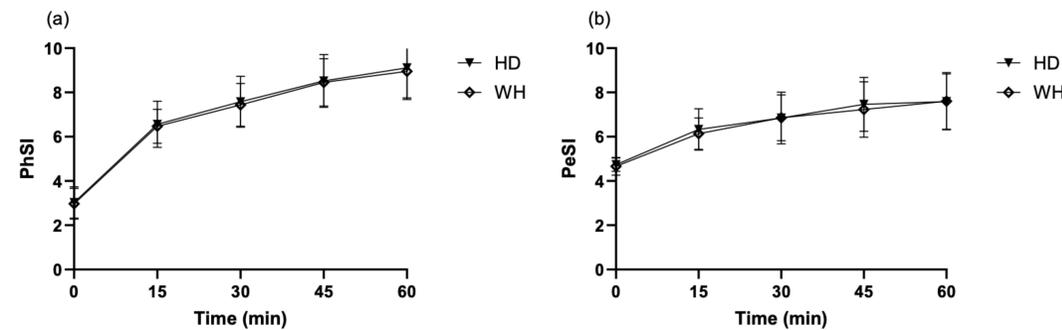


Figure. 1 Change in physiological strain index (PhSI) and perceptual strain index (PeSI) during 60-minute cycling between HD and WH environmental conditions

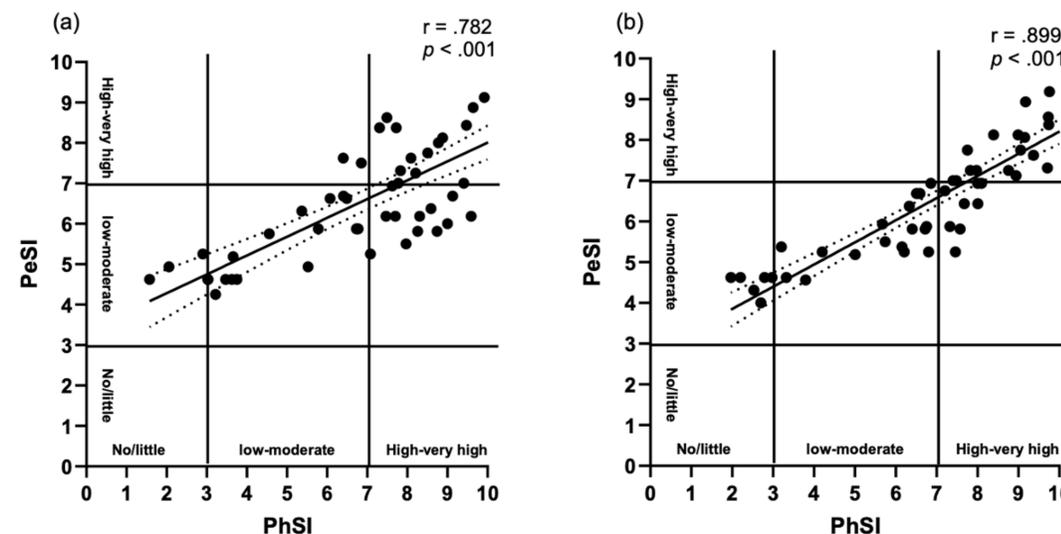


Figure. 2 The physiological strain index (PhSI) correlated to the perceptual strain index (PeSI) in (a): hot-dry (HD) and (b): warm-humid (WH) environmental conditions. Vertical and corresponding horizontal lines define the three strain index categories: no/little (0–2.9), low–moderate (3–6.9), and high–very high (7–10).

Practical Applications

Our data suggest that PeSI is a reliable alternative for monitoring individual heat strain in the absence of direct physiological strain measurement in field settings such as athletic, occupational, and military operations



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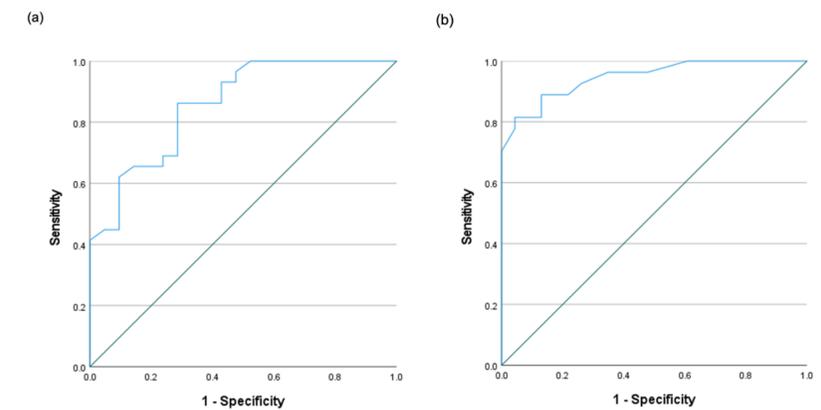


Figure. 3 The receiver operating characteristic curves for the perceptual strain index with reference to high (PhSI of seven) physiological strain at (a): HD and (b): WH conditions. The areas under these curves are 0.858 (95% confidence interval: 0.756–0.960) at HD condition and 0.947 (95% confidence interval: 0.890–0.999) at WH conditions. A perfect prediction will have an area of 1.0, while completely random predictions will have an area of 0.

Table. 1 Predictive analysis for physiological strain index (PhSI) by perceptual strain index (PeSI) in hot-dry (HD) and warm-humid (WH) conditions

Variable	HD (95%CI)	WH (95%CI)
Sensitivity	.621 (.468-.753)	.731 (.571-847)
Specificity	.905 (.749-.968)	.958 (.833-991)
LR+	6.517 (2.102-20.211)	17.538 (3.464-88.808)
LR-	.419 (0.279-.630)	.281 (.164-.480)

LR+: positive likelihood ratio; LR-: Negative likelihood ratio; CI: confidence interval

Conclusions

PeSI adequately differentiates between and predicts physiological strain across different hot environments with equivalent WBGT

References

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