Reliability and validity of novel methods in the assessment of cold-induced shivering

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RELIABILITY AND VALIDITY OF NOVEL METHODS IN THE ASSESSMENT OF COLD-INDUCED SHIVERING.

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INTRODUCTION

CONTEXT: Shivering defined as the ‘simultaneous asynchronous contraction of the muscle fibres in both flexor and extensor muscles’ (1). Both the onset and magnitude of shivering are influenced by corresponding reductions in skin or deep body temperature, but also a range of non-thermal factors (2-5). Despite various forms of shivering quantification in research and practice, a direct comparison between metrics has yet to be performed, specifically in quantifying shivering onset.

AIM: The purpose of this methodological study was twofold:
1. To compare the test-retest reliability of four independent metrics for the assessment of shivering onset; whole-body oxygen uptake (V̇O₂), electromyography (EMG), mechanomyography (MMG), and hide side assessment shivering scale (BSAS).
2. To compare the validity across metrics as appropriate methodological tools for shivering research.

METHODOLOGY

PARTICIPANTS: Ten healthy volunteers (age, 23 ± 3 yrs; stature, 1.75 ± 0.07 m; mass, 71.1 ± 11.5 kg).

DESIGN: Repeated measures design, visiting the laboratory on three occasions, undertaking identical sessions (Fig 1). Prior to cold exposure, participants remained seated in a thermoneutral environment (21°C) for 20 mins allowing skin temperature to stabilise.

RESULTS:

RELIABILITY: Table 1: Test-retest reliability of four independent metrics for the assessment of shivering onset during lower body cold water immersion.

Table 1: Test-retest reliability of four independent metrics for the assessment of shivering onset during lower body cold water immersion.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Trial 1 Mean</th>
<th>Trial 2 Mean</th>
<th>Mean Diff</th>
<th>CV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>V̇O₂</td>
<td>2120 ± 622</td>
<td>2057 ± 560</td>
<td>37 ± 10</td>
<td>1.8</td>
</tr>
<tr>
<td>常 相差</td>
<td></td>
<td></td>
<td>3.7</td>
<td>1.8</td>
</tr>
<tr>
<td>常 相差</td>
<td>2057 ± 560</td>
<td>2120 ± 622</td>
<td>37 ± 10</td>
<td>1.8</td>
</tr>
<tr>
<td>BSAS</td>
<td>2516 ± 768</td>
<td>2191 ± 776</td>
<td>325 ± 72</td>
<td>13.0</td>
</tr>
<tr>
<td>常 相差</td>
<td></td>
<td></td>
<td>325 ± 72</td>
<td>13.0</td>
</tr>
</tbody>
</table>

NOTE: Mean CVs are shown in italics and represent the mean coefficient of variation across trials, with a mean CV of 3% ± 50% (Table 1).

BSAS = subjective stages; CV = coefficient of variation; mean = mean of all trials; SD = standard deviation.

VALIDITY: Figure 3: Representation of signal to noise ratio across three independent metrics in the assessment of shivering onset. NO: data are means of three repeated trials across subjects N = 5. Intermittent shivering onset defined as visual inspection of inflection points.

BSAS = subjective stages; CV = coefficient of variation; mean = mean of all trials; SD = standard deviation.

DISCUSSION

RELIABILITY: In view of the ICC values observed, all metrics provide a good-excellent degree of test-retest reliability in the assessment shivering onset (Table 1). Interestingly, time elapsed related to cold exposure provided a more consistent predictor of shivering onset than core temperature; thus evidence is presented for the addition of a temporal element in the regulation of thermal homeostasis.

VALIDITY: Chronologically, MMG and EMG were similar in the identification of shivering onset, while a lag was seen in V̇O₂ derived identification (Fig 3). As such, MMG and EMG present a suitable choice for researchers requiring real-time objective identification of shivering onset. BSAS 1 preceded any activity registered via other metrics, yet comparing objective metrics with BSAS equivalent stages (i.e. BSAS stage 2 vs. objective intermittent shivering, and BSAS 3 vs. objective constant shivering), a lag was seen in identification via BSAS. Note, considerable variability exists in the magnitude of the delay. Assessment of signal to noise ratio favoured EMG (SNR,1.43 ± 2.11) as an analytical tool, followed by MMG (SNR,0.67 ± 0.84) and finally V̇O₂ (SNR,0.37 ± 0.66) (Fig 4).

INTEGRATION OF METRICS: Each metric in isolation presents a series of key limitations, thus development of an integrated measure of shivering onset, in both flexor and extensor muscles (Fig 13). For example, V̇O₂ has a high degree of sensitivity to shivering, whilst EMG and MMG have a high degree of specificity. Therefore, a combination of these metrics is required to optimise the detection of shivering.

Intermittent shivering onset: SNR > 1.5.

REFERENCES / CONFLICTS OF INTEREST


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