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Short Communication

## Affective response to whole-body cryotherapy: Influence of sex, body mass index, age, time of day, and past experience

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## ABSTRACT

**Objective:** Whole-Body Cryotherapy (WBC) has seen a recent surge in popularity with patients with inflammatory conditions, athletes, and even people seeking to improve general health and quality of life. WBC treatment usually requires participation in a dozen of 3-min long sessions. But compliance is considered difficult due to possible cold-induced unpleasant sensations. Based on hedonic psychology assumptions, ratings of pleasure-displeasure experienced during a task or activity may be important to understand individual differences in attendance.

**Methods:** Two hundred fifty nine customers from two French cryocenters took the Feeling Scale immediately after their first WBC session.

**Results:** End affect appeared to be negatively valenced ( $M = -1.85$ ,  $SD = 1.38$ , 95 % confidence interval: -2.02 to -1.68). Additional statistical analyses revealed a moderating influence of past experience, in women only. Similarly, BMI was found to be negatively associated with displeasure in women, but not in men.

**Conclusion:** These findings are discussed and further research directions are suggested.

## 1. Background

Since the late 1990's, whole-body cryotherapy (WBC) is growingly used in clinical settings. WBC consists of brief exposure (usually 3 min) to cold air in a special temperature-controlled cryochamber where air temperature is maintained at very low levels (usually  $-110^{\circ}\text{C}$ ). Exposure to cold temperature in the cryochamber triggers significant physiological responses of the body (for review see <sup>1</sup>). In particular, the temperature receptors in the skin send information to the brain which responds with an attempt to restore balance. The brain attempts to maintain core temperature by carrying out vasoconstriction of blood vessels (e.g., <sup>2</sup>). Blood is retained in the body's core as a means of protecting vital organs. After the 3 min cryostimulation is completed, the blood vessels vasodilate and there is increased blood flow to the skin and extremities. During the process, blood becomes enriched with oxygen, nutrients, and there is release of endorphins and anti-inflammatory proteins (e.g. <sup>3</sup>). Empirical studies have provided evidence that WBC programs (7–14 days of daily sessions) can alleviate inflammation, swelling and pain in arthritis (e.g., <sup>4</sup>), osteoarthritis (for review see <sup>5</sup>,

and ankylosing spondylitis (e. g., <sup>6</sup>). Disease activity decreased slightly, but there were no significant differences between the therapy groups. WBC is also used for pain relief in patients with fibromyalgia (e.g. <sup>7</sup>), and patients with atopic dermatitis. <sup>8</sup> Importantly, WBC has very recently been shown to positively influence cognitive functioning and mental health, with studies indicating significant alleviation of depressive symptoms in clinically diagnosed depressed patients <sup>9</sup> and memory improvements in patients with mild cognitive impairment. <sup>10</sup> Finally, WBC is used more and more frequently as a wellness method in healthy subjects to help maintain good health (e.g., <sup>11</sup>).

Behavioural health treatments such as WBC can help patients as well as disease-free individuals live healthier and happier lives; however, the benefits of those treatments are not fully realized because of non-adherence. In the medical treatment literature, rates of nonadherence to behavioral treatments have been found to be 20%–40% for acute treatment regimens (i.e., treatment duration < 2 weeks), 30%–60% for chronic treatment regimens (i.e., treatments prescribed for patients with chronic illnesses), and 50%–80% for preventative treatment regimens. <sup>12</sup>

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In the context of hedonic psychology, it is well documented that affective memories associated with the negative or positive emotional state experienced during a given task or activity plays a central role in the decision whether or not to repeat that activity (e.g. <sup>13</sup>).

Consequently, what we present here is an exploratory study in which the main purpose was to investigate the affective response immediately following a 3-min long whole-body cryostimulation at  $-110^{\circ}\text{C}$  by examining the moderating influence of selected variables (gender, age, body mass index, past experience, time of day).

## 2. Methods

### 2.1. Participants

Two hundred fifty nine healthy adults ( $M = 40.1$  years,  $SD = 16.3$  years, 56.0 % males) suffering from transient insomnia ( $n = 155$ , i.e., 59.9 %), mild joint pain/stiffness ( $n = 78$ , i.e., 30.1 %), or mild stress ( $n = 26$ , i.e., 10.0 %) volunteered for our study. All participants were recruited from non-patients customers of two whole-body cryotherapy (WBC) centers in northeastern France (CRYOTERA, Bezannes,  $n = 176$ ; CLINALLIANCE, Villiers-sur-Orge,  $n = 83$ ). Protocol and procedures were similar in these two centers. Among these 259 participants, 147 (i.e., 56.8 %) were unaccustomed users of WBC, and 112 (i.e., 43.2 %) had experienced it at least once in the last 6 months. The duration of WBC treatment was 14 days (including ten 3-min long WBC sessions). All participants completed a medical questionnaire which ensured that they did not have cardio-respiratory contra-indications to participate in whole-body extreme cold exposure; and that they were not currently taking any medications for health problems. All participants provided a written informed consent and the study was conducted in line with the principles of the Helsinki Declaration and its following amendments.

### 2.2. Procedure

The study employed a descriptive / comparative survey design. Between October 2019 and February 2020 volunteers were recruited on-site from users who just finished taking the first WBC session of their prescribed cycle (10 sessions). About sixty-four percent of recruited participants ( $n = 167$ ) completed their session in the afternoon (> 5 p. m.), whereas the remaining ones completed it before 10 a.m. All WBC sessions at this cryocenter followed a standardized protocol. Subjects were minimally dressed (bathing suit, socks, clogs, headband, and surgical mask to avoid direct exhalation of humid air). Then they entered a vestibule chamber at  $-60^{\circ}\text{C}$  where they stayed for about 30 s of body adaptation before passing to a cryochamber at  $-110^{\circ}$  where they had to remain for 3 min. The double tank cryogenic chamber was a MECOTEC Inc., model CRYOAIR  $-110^{\circ}\text{C}$  (Mecotec Cryoair, Pforzheim, Germany).

### 2.3. Instruments

The Feeling Scale (FS <sup>14</sup>) was used to measure affective valence (i.e., pleasure / displeasure) after the WBC sessions. Participants rated their current feelings on this eleven point bipolar scale ranging from -5 to +5 with verbal anchors of « very bad » (-5), « bad » (-3), « fairly bad » (-1), « neutral » (0), « fairly good » (+1), « good » (+3), and « very good » (+5). Previous research has confirmed the validity of the FS as an appropriate measure of affective valence (e.g., <sup>15</sup>).

Basic anthropometric data (age, height, weight) were also collected and recorded on a separate form.

### 2.4. Statistical analyses

The data were analyzed with a 2 (gender) x 2 (time of day) x 2 (past experience) analysis of variance (ANOVA), with the level of alpha set at .05. Partial eta squared ( $\eta^2_p$ ) was used as a measure of effect size. In

accordance with Cohen's recommendations, partial eta squared values of .01, .06, and .14 were taken to imply small, medium, and large effect sizes, respectively. <sup>16</sup> All means were expressed with 95 % confidence intervals.

## 3. Results

Overall, the mean pleasure level immediately following WBC was negative;  $M = -1.85$  ( $SD = 1.38$ , 95 % confidence interval = -2.02 to -1.68), with 232 participants (89.6 %) reporting a score below the neutral point (0) on the Feeling Scale (FS). As can be seen in Table 1 there was a slight difference in the mean FS score for females compared to males; but this difference did not reach statistical significance,  $F(1, 251) = 2.45$ ,  $p = .119$ ,  $\eta^2_p = .01$ .

Similarly, the average FS score appeared to be lower for participants who took their session in the morning compared to those who took their session in the afternoon, but again this difference failed to reach significance;  $F(1, 251) = 3.70$ ,  $p = .056$ ,  $\eta^2_p = .01$ .

In the other hand, a significant main effect for level of experience was found. As shown in Table 1, those who were new to WBC reported more displeasure than WBC-experienced participants;  $F(1, 251) = 5.89$ ,  $p = .016$ ,  $\eta^2_p = .02$ .

Importantly, there was a significant interaction between gender and level of experience so that this difference between novices and experienced users was found in women only;  $F(1, 251) = 5.15$ ,  $p = .024$ ,  $\eta^2_p = .02$ . For male participants, the FS score did not differ between first-time and recurrent users.

Neither the other 2-way interactions (gender x time of day and past experience x time of day) nor the 3-way interaction (gender x time of day x past experience) were significant.

The FS score was positively correlated with BMI in women ( $r = .23$ ,  $p = .013$ ) but not in men ( $r = .14$ ,  $p = .094$ ). For both genders, age had no association with pleasure/displeasure ( $r = .12$ ,  $p = .219$  in women, and  $r = .15$ ,  $p = .071$  in men).

## 4. Discussion

Based on past research showing that the way people feel at the end of an activity session largely determines one's global affective evaluation of that activity, which in turn influences future behavioural decisions to stick (or not) with the activity, the purpose of the present study was to measure the affective response (i.e., pleasant vs. unpleasant feelings) immediately after extreme cold exposure in a large and diverse sample of WBC users.

To our knowledge, this is the first study to provide quantitative data on this subject. Considering all participants taken as a whole, the affective valence reported immediately following a 3-min long WBC session at  $-110^{\circ}\text{C}$  was found to be in the negative side (i.e., displeasure) of the Feeling Scale, between -2 and -1 (« fairly bad » to « neutral »). This finding is very similar to what can be observed at the end of physical exercise above the ventilatory threshold; with values around -0.5 in a blank environment (i.e., without music and/or video; Jones, Karageorghis, & Ekkekakis, 2014).

In line with what all past studies had reported (for review, see <sup>17</sup>) our findings revealed that the discomfort associated with cold exposure declined with repetition, a phenomenon called « habituation ». However, this only applied to women in our study. At this stage we can provide no explanation for this sex-specific difference. Past studies suggested that oxytocin may facilitate the process of habituation-familiarization (e.g., <sup>18</sup>) and it is well-established that oxytocin levels tend to be higher in females compared to males (e.g., <sup>19</sup>). Obviously this is a speculative explanation and future investigations are needed to confirm it.

Although of small magnitude, the positive correlation between BMI and the FS score in women is another observation consistent with a

**Table 1**

Feeling Scale mean ratings and standard deviations as a function of gender, time of day, and past experience.

	Gender	Time of Day	Past Experience	n	M	SD	F(1, 251)	p	$\eta^2_p$
<b>Total</b>				259	-1.85	1.38			
<b>Gender (1)</b>	men			145	-1.69	1.38	2.45	.119	.01
	women			114	-2.05	1.37			
<b>Time of Day (2)</b>		morning		92	-2.01	1.18	3.70	.056	.01
		afternoon		167	-1.76	1.48			
<b>Past Experience (3)</b>			no	147	-2.00	1.31	5.89	.016	.02
			yes	112	-1.65	1.45			
<b>(1) x (2)</b>	women	morning		40	-2.18	1.08	< 1	.831	.00
	women	afternoon		74	-1.99	1.50			
	men	morning		52	-1.88	1.24			
	men	afternoon		93	-1.58	1.44			
<b>(1) x (3)</b>	women		no	67	-2.39	1.24	5.15	.024	.02
	women		yes	47	-1.57	1.41			
	men		no	80	-1.68	1.29			
	men		yes	65	-1.71	1.49			
<b>(2) x (3)</b>		morning	no	40	-2.20	0.94	< 1	.692	.00
		morning	yes	52	-1.87	1.33			
		afternoon	no	107	-1.93	1.43			
		afternoon	yes	60	-1.47	1.53			
<b>(1) x (2) x (3)</b>	women	morning	no	18	-2.56	0.86	< 1	.637	.00
	women	morning	yes	22	-1.86	1.17			
	women	afternoon	no	49	-2.33	1.36			
	women	afternoon	yes	25	-1.32	1.57			
	men	morning	no	22	-1.91	0.92			
	men	morning	yes	30	-1.87	1.46			
	men	afternoon	no	58	-1.59	1.40			
	men	afternoon	yes	35	-1.57	1.52			

number of previous studies which highlighted that those who report better cold tolerance are more likely to have a higher BMI (e.g. <sup>20</sup>). However, our observed sex-related difference for the association between BMI and affective response to WBC was not expected. Future research will be needed to verify the robustness of this effect, and provide plausible explanations for this.

All the findings reported here should be interpreted in the context of several limitations. First, our study included individuals with mild-to-moderate health conditions (mainly transient insomnia or joint pain) who were otherwise healthy adults. Therefore, results should be confirmed within clinical populations. Second, no data are available to assess whether participation in WBC sessions was higher in those participants who reported neutral or even positive affect at the end of their first session. It was our intention to provide empirical data on overall attendance and how it relates to participants' affective response to their initial session; however, due to the COVID-19 shutdown, this investigation could not be conducted.

## 5. Conclusion

Three main findings emerged from the present exploratory study: (1) most participants rated WBC as being slightly-to-moderately unpleasant immediately after completing their first session, (2) past experience with WBC might positively moderate the negative effects of WBC on affect (particularly in women), and (3) those with higher BMI tended to report less negative feelings (once again this was seen for women but not for men). Now, there is an urgent need to empirically document the effects of end-session affect on subsequent adherence to WBC.

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## Authors statement

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Legrand designed the study, performed research, collected data, analyzed, and interpreted the data, and wrote the paper. Beaumont designed the study, performed research, analyzed, and interpreted the data. Bogard designed the study, and performed the statistical analyses. Bouchet and Blancheteau collected data. Polidori designed the study and prepared the final version of the paper.

## Declaration of Competing Interest

None to declare from any author.

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