

# Retraction: Impact of cold exposure on life satisfaction and physical composition of soldiers

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The authors and journal are retracting this paper. After a complaint, the authors audited their data and identified errors in the analysis including the incorrect inclusion of subjects from other ongoing studies. On the basis of this, the study findings are now unreliable. In addition, the study design is ambiguous. The authors apologise and say that the errors were unintentional.

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# Impact of cold exposure on life satisfaction and physical composition of soldiers

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## ABSTRACT

**Introduction** Optimal mental state and physical fitness are crucial factors affecting training of military personnel. Incorporating components aimed at improving mental status and physical composition of soldiers into training programmes can lead to better outcomes. Previously, cold exposure has been used to promote human health in multiple ways, with a plethora of reported benefits. Thus, the aim of this study was to examine the effect of regular cold exposure on the psychological status and physical composition of healthy young soldiers in the Czech Army. **Methods** A total of 49 (male and female) soldiers aged 19–30 years were randomly assigned to one of the two groups (intervention and control). The participants regularly underwent cold exposure for 8 weeks, in outdoor and indoor environments. Life Satisfaction Questionnaire and InBody 770 device were used to evaluate life satisfaction and body composition, respectively. Zung Self-Rating Anxiety Scale was used to assess anxiety produced by cold exposure.

**Results** Theoretical and practical training in cold immersion in the winter did not induce anxiety. Regular cold exposure led to a significant ( $p=0.04$ ) increase in life satisfaction and in self-perceived sexual satisfaction compared with the pre-exposure measurements. Furthermore, a considerable increase (6.3% compared with the pre-exposure period) was observed in self-perceived health satisfaction; the change was borderline significant ( $p=0.052$ ). In men, there was a reduction in waist circumference (1.3%,  $p=0.029$ ) and abdominal fat (5.5%,  $p=0.042$ ). Systematic exposure to cold significantly lowered perceived anxiety over the entire test group ( $p=0.032$ ).

**Conclusion** Cold water exposure can be recommended as an addition to routine military training regimens. Regular exposure positively impacts mental status and physical composition, which may contribute to the higher psychological resilience. Additionally, cold exposure as a part of military training is most likely to reduce anxiety among soldiers.

## INTRODUCTION

Cold exposure refers to the active and voluntary cooling of specific body parts or the entire body with cold air or water. It is usually performed by immersing the body in open water during the winter or cooling it under a cold shower in domestic conditions. Cold, as a means of positively influencing human health, has been used to support a healthy lifestyle in a variety of ways, an example being the Wim Hof method.<sup>1</sup> Interestingly, the first mention of beneficial effects of cold dates back to 3500 BC.<sup>2</sup> Prior research on the relationship between cold exposure and morbidity has reported

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Regular cold exposure increases resilience to stress factors

## WHAT THIS STUDY ADDS

⇒ Theoretical and practical training in cold immersion in the winter does not induce anxiety.  
⇒ Regular exposure to cold increases self-perceived health and sexual satisfaction and reduces waist circumference and abdominal fat.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Cold water exposure as a supplement to routine military training may be a pleasant diversion while positively affecting the well-being of soldiers.

that cold exposure is associated with a reduction in morbidity. However, the number of days of illness in adults remained unchanged (ie, if individuals become ill, they will be treated for the same length of time as they would have been treated if not exposed to cold).<sup>3</sup> In the past, cold showers or cold water swimming has been used as a possible non-pharmacological supportive treatment for depression, but without satisfactory results.<sup>3, 4</sup> Regular cold exposure has been shown to increase resilience to stress factors<sup>5</sup> and improve psychological well-being.<sup>6</sup> It is also known to exert a positive effect on accelerating recovery after high physical stress.<sup>7</sup> Furthermore, cold exposure has been demonstrated to lower BP, suggesting its utility as a preventive measure against cardiovascular diseases.<sup>8–10</sup> At the same time, short-term exposure to cold (up to 1 hour in a cold bath, under optimal cold exposure conditions as defined in the literature) appears to be safe, with no significant adverse side effects (either short term or long term).<sup>11, 12</sup>

Both optimal mental state and physical fitness are fundamental factors that significantly affect a soldier's ability to train in the armed forces environment.<sup>13, 14</sup> Moreover, the global trend of rising weight and obesity has not spared the military professionals, potentially limiting their physical capabilities.<sup>15–17</sup> Therefore, our study aimed to assess the effect of regular cold exposure on the psychological status and physical composition of a specific group of healthy young soldiers in the Czech Army. The Life Satisfaction Questionnaire (LSQ) designed by Fahrenberg *et al*<sup>18</sup> and the InBody 770 device were employed for assessment of the physical composition. In addition, the Zung Self-Rating



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**Table 1** Age characteristics of the study population (mean±SD)

	Intervention group				Control group			
	N	Age	Min	Max	N	Age	Min	Max
All	25	23.9±3.6	19	30	24	23.4±3.1	19	30
Female	8	22.0±2.0	20	26	7	23.1±2.5	19	26
Male	17	24.8±3.8	19	30	17	23.5±3.3	19	30

Statistical analysis did not show any differences between both groups.  
Max, maximum; Min, minimum; N, number of persons.

Anxiety Scale (Zung SAS) was used to evaluate anxiety produced by cold water training.<sup>19</sup>

## METHODS

### Participants

The study was conducted between January 2022 and May 2022. Soldiers of the Czech Armed Forces aged 19–30 years were invited to participate; all participants provided written informed consent for participation in this research.

A total of 49 soldiers (15 women and 34 men) participated in the study and were randomly divided into two groups (control and intervention) before the start of the experiment (table 1). The participants had no prior experience with regular cold exposure, were in good physical condition based on an annual medical evaluation (mandatory in the Czech Army), were satisfied with their physical status, and had no plans to change their regular sporting or dietary habits. Before and during the study, they did not take any medications and did not suffer from any health restrictions. Both groups were prohibited from changing their eating habits, sporting activities and other regular activities during the study. Participants were also asked to maintain a diary to track their physical activity (date, time and duration), individual cold exposure sessions (date, time and duration) and perceived subjective feelings.

### Intervention group

The intervention group received preliminary training (duration: 4 hours) on the benefits of cold exposure on the body, the impact of cold environment on the human body and the body's response to this impulse. An important aspect was safety warnings on how to find a suitable place for cold exposure (open water areas, running water, etc). An initial theoretical preparation was conducted for exposure to cold in the form of immersion in cold water in winter. Participants were found to be familiar with immersion techniques, safety principles of immersion and cold exposure. After theoretical preparation, the actual immersion was performed in which the participants were immersed up to their shoulders in open water for 2 min. The first immersion was at 3°C, and the air temperature was 4.2°C. Subsequently, the participants were asked to come out of the water and actively warm up in cool outside air using light physical activity until they reached a subjective perception of being warm. Then, after, the participants were instructed to dry off and dress 10 min after leaving cool water. The same process was practised periodically throughout the 8 weeks of the study. During this period, cold exposure consisted of outdoor immersion (a lake, a reservoir or running water, air/water temperature ≤6°C, ≥ 1/week, duration ≥30 s) and a cold shower (water temperature ≤10°C regardless of the room temperature, ≥4/week, duration ≥30 s).

### Control group

The control group completed the questionnaire survey and physical measurements on the same day and time as the intervention group, to ensure similar conditions during the investigation.

### Psychological screening

A questionnaire survey was conducted at the beginning (before theoretical preparation) and end of the experiment (8 weeks apart). The LSQ was used to measure life satisfaction, which comprised of the following domains: health, job and employment, finance, leisure time, marriage and partnership (MAP), relationship with children (CHIL), own person, sexuality, friends, family and relationships, and living and housing.<sup>18</sup> We did not evaluate MAP and CHIL in the present study because not every participant had a partner or a child at the time of the survey. This questionnaire has been used previously in study mapping life satisfaction among soldiers.<sup>14</sup>

Following the theoretical preparation, we also conducted a Zung SAS evaluation of all participants.<sup>19</sup> This questionnaire has been widely used to assess psychological resilience in young soldiers<sup>20</sup> and is suitable for identifying periods of stress.<sup>21</sup> The questionnaire contains 21 items with values ranging from 1 to 4, defining the frequency of the described phenomenon. A score of 25–44 indicates a normal state.<sup>19</sup> Both groups completed the questionnaire twice in the morning and afternoon, on the day of cold water exposure training.

### Body composition

Based on electrical impedance analysis, the InBody 770 device (InBody Co, Seoul, Korea) was used to assess the body composition (including the amount of fat, visceral fat, muscle mass and total weight) of each participant.<sup>22 23</sup> Testing was performed on an empty stomach, at a predetermined time in the morning, according to the manufacturer's instructions. First, the height, weight and waist circumference of each participant were manually measured. These measurements were performed by a single-blinded researcher who was experienced in operating the device but had no information on the group assignment. Collected data were then entered into the InBody 770 device and the obtained results were separated according to gender.

### Feedback

Finally, the participants were asked how they felt about the research and whether they would continue with cold water exposure in their daily routine. These questions were posed to the participants 7 and 160 days after the experiment to elicit feedback on the study.

### Statistical analysis

The Shapiro-Wilk test was used to assess the distribution of the data. Normally distributed data were analysed using a parametric paired t-test. For women, we used a non-parametric test for data evaluation, which was more appropriate for the small sample. Thus, data derived from female participants and other non-normally distributed data were analysed using the Wilcoxon signed-rank test (Monte Carlo test, confidence level: 99%, number of samples: 10 000). Differences were considered statistically significant at  $p \leq 0.05$ .

## RESULTS

All participants completed the study and met the minimum number of cold water exposure sessions with an average of

**Table 2** Change in perceived anxiety before and after the theoretical training and first immersion into the cold lake water during the winter measured by Zung SAS (mean±SD)

	1st measurement	2nd measurement	P value
Intervention group (N=25)	41.1±11.0	39.3±11.2	<b>0.032 (0.031)</b>
Control group (N=24)	40.9±9.3	41.8±8.2	0.721 (0.730)

Bold significant differences between the first and second measurements:  $p \leq 0.05$  (tested by Wilcoxon test; in brackets, we state the exact test as Monte Carlo). SAS, Self-Rating Anxiety Scale.

5.1±0.4 cold showers and 1.2±0.2 open water immersions, per week. All exposures met the set conditions.

### Perceived anxiety

Theoretical training and active immersion in cold lake water during the winter did not produce anxiety. In contrast, there was a significant decrease of 4% in the anxiety scores measured by the Zung SAS questionnaire (table 2).

### Life satisfaction

The first measurement revealed no gender differences in the life satisfaction scores. Thus, data from both male and female participants were pooled. The results did not show any significant changes in the overall life satisfaction in either group. However, this trend was inconsistent across all participants in each group. In the intervention group, 56% of the participants experienced an average improvement of 10% in overall life satisfaction, followed by 12% who experienced no change and 32% who experienced a 4% average decrease in perceived life satisfaction. In the control group, 50% showed an improvement in overall life satisfaction by an average of 4%, 18% did not experience any change and 32% experienced an average decrease of 4% in overall life satisfaction.

On the other hand, within individual parameters, a significant increase of 6.2% was observed in perceived sexual satisfaction in participants who started to practise regular cold exposure compared with the first measurement. Self-satisfaction with health was considered to be marginally significant, with a 6.3% increase (table 3).

**Table 3** The life satisfaction before and after the periodical exposure to cold water for 8 weeks (mean±SD)

	Intervention group (N=25)			Control group (N=24)		
	Before	After	P value	Before	After	P value
HLTH	39.6±5.0	40.2±3.4	0.052 (0.031)	37.8±5.9	36.6±6.0	0.396 (0.414)
JAE	39.4±6.1	40.2±5.6	0.081 (0.816)	37.8±6.0	39.1±5.7	0.179 (0.183)
FIN	38.8±7.1	41.0±7.5	0.084 (0.083)	40.1±7.1	40.8±9.9	0.736 (0.746)
LT	35.0±5.0	36.2±7.2	0.688 (0.699)	33.4±6.6	33.0±8.0	0.749 (0.762)
MOP	39.2±5.1	40.2±5.9	0.252 (0.263)	36.6±7.6	37.5±7.1	0.106 (0.111)
SEX	38.5±5.5	40.7±5.6	<b>0.045 (0.046)</b>	38.9±7.6	39.3±8.1	0.101 (0.103)
FFR	33.2±4.2	33.8±4.0	0.713 (0.730)	33.6±5.0	33.8±5.5	0.849 (0.869)
LAH	34.2±5.1	34.6±5.7	0.566 (0.575)	33.3±6.5	33.8±5.9	0.391 (0.408)
SUM LSQ	259±28	269±29	0.178 (0.185)	254±36	258±37	0.939 (0.947)

Bold significant differences before and after the periodical exposure to cold water:  $p \leq 0.05$  (tested by Wilcoxon test; in brackets, we state the exact test as Monte Carlo). FFR, friends, family and relationships; FIN, finance; HLTH, health; JAE, job and employment; LAH, living and housing; SUM LSQ, Summary Life Satisfaction Questionnaire; LT, leisure time; MOP, my own person; SEX, sexuality.

**Table 4** Male and female body composition measured by the InBody 770 device before and after the periodical exposure to cold water for 8 weeks (mean±SD)

	Intervention group			Control group		
	Male (N=17)		P value	Male (N=17)		P value
	Before	After		Before	After	
Weight (kg)	85.2±9.7	84.6±9.6	0.132	83.1±8.5	81.1±8.8	0.989
BMI (kg)	25.9±2.8	25.8±2.8	0.201	24.4±2.8	25.2±2.8	1.000
WC (cm)	87.1±7.8	86.0±7.1	<b>0.029</b>	84.6±8.2	84.6±6.1	0.976
BFM (kg)	14.3±6.8	13.9±6.7	0.262	12.9±5.6	12.8±5.0	0.710
FFM (kg)	70.9±5.4	70.8±5.7	0.606	71.7±6.5	70.3±6.3	0.678
SSM (kg)	40.5±3.2	40.5±3.5	0.830	40.1±3.1	40.2±3.1	0.907
SSM (%)	47.8±3.3	48.0±3.3	–	48.5±3.2	48.5±3.0	–
PBF (%)	16.3±5.9	16.3±5.9	–	15.2±5.5	15.2±5.1	–
VFA (cm <sup>2</sup> )	60.3±27.9	57.7±25.1	<b>0.027</b>	54.6±26.9	52.2±24.0	0.794
Female (N=7)						
Weight (kg)	59.3±8.9	58.9±8.2	0.900	58.1±6.5	58.4±6.3	0.398
BMI (kg)	21.5±2.1	20.9±1.8	0.000	19.9±2.2	21.8±2.1	0.400
WC (cm)	67.1±4.2	67.0±3.6	0.810	69.6±7.2	69.6±6.6	0.865
BFM (kg)	11.5±3.4	11.5±3.3	0.799	12.5±4.1	12.4±4.1	0.600
FFM (kg)	47.8±5.5	47.6±5.5	0.205	46.4±5.0	46.0±4.9	0.612
SMM (kg)	26.6±3.4	26.5±3.2	0.205	25.7±3.0	25.5±2.9	0.735
SSM (%)	44.9±1.3	45.1±1.2	–	43.7±3.1	43.6±3.2	–
PBF (%)	19.0±3.4	18.9±3.0	–	21.1±5.3	21.1±5.5	–
VFA (cm <sup>2</sup> )	43.9±14.3	41.2±12.4	0.327	49.1±16.0	47.8±15.9	0.176

Bold significant differences before and after periodical exposure to cold water:  $p \leq 0.05$ . Male data were evaluated using the t-test. Due to the small sample size, female data were analysed using the Wilcoxon test. BFM, body fat mass; BMI, body mass index; FFM, fat-free mass; PBF, percent body fat; SMM, skeletal muscle mass; VFA, visceral fat area; WC, waist circumference.

### Body composition

In the male intervention group, we observed a significant reduction of 1.1 cm in waist circumference, which was associated with a 5.5% decrease in the mean value of abdominal fat. In contrast, we did not observe any significant differences in the male control group and either of the female (intervention and control) groups (table 4).

### Feedback

At the end of the study, 84% of the participants responded that they would continue to practise cold exposure. Only 12% were unsure whether they would continue, and 4% said that they would not continue with cold exposure. A large proportion of participants in the intervention group (92%) responded that regular cold exposure helped them improve in their work-related tasks. Only 4% of the participants did not know if cold exposure had helped them, while 4% reported deterioration in their work performance.

At the 160-day follow-up, 84% participants reported continuing cold exposure practice. Only 16% participants did not continue exposure. In the intervention group, 88% of the participants responded that regular exposure helped them improve their work-related tasks, while 12% did not perceive any subjective benefit.

### DISCUSSION

The current study was part of a comprehensive programme developed in the Czech Army to help soldiers enhance their resilience and physical performance. The programme consisted of a variety of approaches, including regular exposure to cold water. This stimulus may act like a double-edged



sword. Extreme exposure to cold water can initiate a stress response<sup>24</sup> and may impair exercise performance.<sup>25</sup> On the contrary, short-term immersion (lasting up to several minutes) does not appear to be stressful. Our survey showed that theoretical training and the first practical cold immersion in the winter did not induce anxiety. In addition, routine cold exposure did not seem to produce stress from a long-term perspective. The diaries kept by the intervention group revealed that the participants started to associate cold exposure with positive feelings as the number of weeks in the experiment increased. This finding is consistent with that of Leppälüoto *et al*,<sup>26</sup> who found that winter swimming (water 0°C–2°C) for 20 s three times a week for 12 weeks did not stimulate the pituitary–adrenal axis but instead resulted in habituation.

Our results also showed that regular cold water exposure improved perceived health and sexual self-satisfaction. In addition, it was associated with reduced waist circumference and abdominal fat in men. We did not observe any significant changes in the body composition of the female participants. However, their group sizes were smaller, and the visceral fat area parameter in the female group exposed to cold water showed a similar decreasing trend as the male group (6.2% vs 5.5% in men). The mechanisms underlying the changes following regular cold water exposure remain unknown. Regarding self-satisfaction with health, the most frequent argument is that cold exposure leads to immunity enhancement, particularly in reducing the frequency of respiratory diseases.<sup>3</sup> So, the parameter could be affected by the perception of the procedure itself, leading to self-reported health satisfaction bias. In contrast, short-term winter swimming is associated with transient norepinephrine release.<sup>26</sup> This hormone triggers both thermogenesis and lipolysis.<sup>27</sup> This can account for the reduced abdominal fat and waist circumference noted in the present study. We may further speculate on the link between central obesity and sexual satisfaction, since another study found a significant relationship between central obesity and the incidence of sexual dysfunction.<sup>28</sup> Such connections suggest that cold water exposure is suitable for experimentation in older male populations where problems with visceral fat content and libido increase with age.<sup>29</sup>

Finally, feedback of the present study showed that participants received cold exposure positively, and many continued the practice even after research completion. Thus, we can assume that this activity could yield similar results when included in winter military training. For training purposes, it is also noteworthy that the Zung SAS questionnaire showed reduced anxiety levels following outdoor cold water immersion. Cold water training methodically associated with more demanding combat and non-combat tasks may help reduce internal tension and stress. This would be a desirable outcome in the military environment, strengthening overall psychological resilience, which could increase a soldier's performance.<sup>13 21 30</sup>

### Limitations

The main limitation of this research is the small sample size and the gender disparity. Furthermore, the small number of women in the study did not allow for a broader interpretation of individual results, especially for human body composition. In addition, due to the small sample size, it was not possible to group the participants on the basis of their occupational classification, rank or unit affiliation. This may have limited the discovery of the possible positive effects on recovery in

individuals exposed to more physically demanding work and their satisfaction with other subscales of the LSQ.

### CONCLUSIONS

This psychological survey showed that cold water exposure increased health and sexual satisfaction among young soldiers. Thus, routine cold exposure can be recommended as an element for promoting healthy lifestyle in terms of mental hygiene. Furthermore, regular cold water exposure helped reduce perceived anxiety, while not significantly reducing abdominal fat and waist circumference in healthy young men. However, it had little effect on the overall change in human body composition with regard to weight, amount of fat or muscle mass. Overall, cold water exposure appears to be a very satisfactory method for use as a component in the training and education of soldiers as well as a supplement that may add an interesting variety to the training methods without posing risks to the participants.

**Contributors** All study design, data collection, manuscript writing. JZ: data collection. PL: data collection; manuscript revision, corresponding author. MB: study design. JP: manuscript revision. HS: data collection.

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**Competing interests** None declared.

**Patient consent for publication** Not required.

**Ethics approval** This study involves human participants and was approved on 22 January 2022 by the Ethics Committee of the University of Defence under the number 001/2021, 5 October 2021. Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available in a public, open access repository. <https://www.vyzkumodlnosti.cz/en/datasets>.

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