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Brief communication

Acute effects of whole-body cryotherapy on sit-and-reach amplitude in women and men

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ABSTRACT

Flexibility is an intrinsic property of body tissues, which among other factors determines the range of motion (ROM). A decrease in neural activation of the muscle has been linked with greater ROM. Cryotherapy is an effective technique to reduces neural activation. Hence, the aim of the present study was to evaluate if a single session of whole-body cryotherapy (WBC) affects ROM. 60 women and 60 men were divided into two groups (control and experimental). After the initial sit-and-reach test, experimental group performed a 150 s session of WBC, whereas the control group stayed in thermo-neutral environment. Immediately after, both groups performed another sit-and-reach test. A 3-way analysis of variance revealed statistically significant *time* × *group* and *time* × *gender* interaction. Experimental groups improved sit-and-reach amplitude to a greater extend than the control group. Our results support the hypothesis that ROM is increased immediately after a single session of WBC.

1. Introduction

Flexibility is an intrinsic property of body tissues, which among other factors determines the range of motion (ROM) achievable without injury at a joint or group of joints. It is often described as a fundamental component of physical fitness required in some sports and physical activities to varying degrees. Numerous studies reported that stretching provides an effective way to increase ROM, although it is not well understood how exactly static flexibility affects dynamic performance.

Maximum ROM is associated with tendon and neuromuscular factors, albeit the extend to which these factors contribute are not well known. Increased ROM would therefore result from either an increased tendon ability to mechanically tolerate stretch loads or a decreased neural activation resulting in greater muscle elongation under the same load. An increase in neural activation of the muscle has been linked to suppressed muscle flexibility. This has been demonstrated with a reduction in the H-reflex after a 10-week stretching training programme, which resulted in a 30% increase in flexibility [5].

One of most common manipulations to reduce neural activation and affect ROM is the use of thermal agents [2]. One example is a warm up prior to exercise, which is known to affect elastic properties of the muscle-tendon system. On the other hand, application of cold agents can reduce neural activity and affect ROM. It has been shown that local cryotherapy decreases nerve conduction velocity and also limits the presence of pain [1]. Furthermore, a recent study suggests that local application of crushed ice can increase ROM of the hip joint [7]. Bleakely and Costello [2] suggest, in their systematic review, that cryotherapy could have beneficial effects on ROM, but the evidence is sometimes conflicting and warrants further research.

One of the common methods in sports medicine and science is whole-body cryotherapy (WBC), which is the exposure of minimally dressed participants to very cold air, either in a specially designed chamber (cryo-chamber) or cabin (cryo-cabin), for a short period of time. Research showed that a decrease in skin temperature after a single 3-min WBC session remains reduced for more than 30 min [10]. WBC is repeatedly used in sports practice to hasten the recovery after high-intensity exercise, but its effects are mainly linked to subjective perception of pain, which could be explained via neural mechanisms [1]. To the authors' best

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knowledge, no studies have examined the acute effects of WBC on ROM. Therefore, the aim of the present study was to test the hypothesis that a single WBC session will increase ROM as measured by the sit-and-reach test.

2. Materials and methods

During the initial physical examination by the qualified physician all participants with increased blood pressure, chronic low back pain and contradictions to WBC were excluded from the study. In total, 60 male and 60 female participants agreed to take part in this study and signed the informed consent approved by the University's medical ethics committee. Participants were then pseudo-randomly divided into a WBC and a control group (30 males and 30 females in each group). Socio-demographic information for each group is presented in Table 1.

Participants were instructed not to perform any physical activity for at least 24 h prior to the experiment. Upon arrival, they were sat down for 30 min wearing only swimwear, woollen socks and wooden clogs to acclimate to the room temperature (22.0 ± 0.5 °C). Following acclimation, each participant performed the sit-and-reach test using a Flex-Tester box (Cranlea, Birmingham, UK). Participants were barefoot with legs fully extended and instructed to lean forward as far as possible with the end position held for at least 2 s. The task was repeated two times.

Following the baseline measurement, the WBC group completed the cryo-session (150 s) in a cryo-cabin (Space Cabin, Criomed Ltd, Kherson, Ukraine). A 150 s duration and set temperature range between −130 and −140 °C. was used as recently recommended [4]. The control group was instructed to perform similar movement (standing rotations) for the same duration in a thermo neutral environment (22.0 ± 0.5 °C). Immediately after the cryo-exposure or control task, the sit-and-reach test was repeated.

The better of the two trials from each time point was taken for further statistical analysis and means ± standard deviations were calculated. The Shapiro–Wilk test was used to test for the normality of the distribution. A 3-way mixed analysis of variance (ANOVA) was used to test the flexibility values for significant differences between the WBC and control group and between the genders. *Gender (2)* and *group (2)* were the inter-subject factors, while the *time(2)* was the intra-subject factor. Before each ANOVA, Mauchly's test of sphericity was performed and appropriate corrections were used when found significant. Additionally, for every statistically significant interaction, *post-hoc* tests with a Bonferroni correction were calculated. The level of significance for all tests was set at $p < 0.05$. All statistical analyses were performed using the IBM SPSS statistics 22.0 software for Mac (Armonk, NY, USA).

3. Results

The differences between the two time points for each gender and group are illustrated in Fig. 1. A 3-way analysis of variance revealed statistically significant *time* × *group* and *time(2) x gender(2)* interaction ($F(1,108) = 49.4$; $p = 0.000$; $\eta^2 = 0.314$ and $F(1,108) = 6.6$; $p = 0.012$; $\eta^2 = 0.057$, respectively). There was a statistically significant *main effect* for the between-gender difference where females reached further than males ($F(1,116) = 21.05$; $p = 0.000$; $\eta^2 = 0.154$).

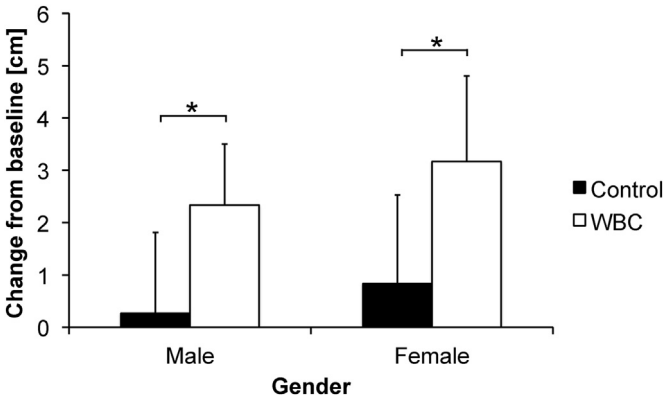

Fig. 1. Graphical representation of the absolute difference in sit-and-reach test compared to the baseline measurement. Statistically significant *time* × *group* interactions ($p < 0.05$) are marked with *. WBC, whole-body cryotherapy.

Post hoc comparisons for males revealed that the WBC group statistically significantly increased the forward reach amplitude ($p = 0.000$), whereas the control group did not significantly differ in forward reach amplitude ($p = 0.348$). For females, both WBC and control group statistically significantly increased the forward reach amplitude ($p = 0.000$ and $p = 0.004$, respectively).

Table 1
Socio-demographic information of the participants (mean ± SD).

	Age (years)	Height (cm)	Weight (kg)	BMI
Male				
WBC	36.4 ± 9.7	181.4 ± 7.8	83.4 ± 12.4	25.5 ± 3.4
Control	31.0 ± 10.1	176.5 ± 6.3	73.5 ± 9.6	23.8 ± 3.5
Female				
WBC	33.8 ± 10.7	167.5 ± 6.8	64.3 ± 9.6	22.9 ± 3.0
Control	31.8 ± 10.0	166.5 ± 6.6	60.0 ± 8.4	23.0 ± 4.3

WBC, whole-body cryotherapy.

4. Discussion

The aim of the present study was to examine the effects of WBC on ROM through a sit-and-reach test. Based on the results we can accept the hypothesis that a single session of WBC increases ROM in men in women.

Our hypothesis was set based on the observations that cryo-stimulation decreases neural activity and allows more elongation of the muscle at a given load. We have observed an increased ROM in the two groups who performed WBC. The main factor associated with these changes is most likely reduced skin temperature and consequential reduction in neural activity. Skin temperature of the lower extremity immediately after 150 s of WBC in a cryo-sauna was reported to fall for more than 10 °C [4,10]. These results are supported with previous findings [8], reporting an increase in active ROM of the hip after applying ice to the hamstrings. This was similarly observed in a study by Newton [15] using a cooling spray. Both of these studies [8,9] concluded that cryo-stimulation reduces pain sensation related muscle spasm allowing longer elongation of the targeted muscle. Cryo-stimulation is linked with a short-term reduced proprioception acuity [3], which further suggests that the somatosensory system is affected when cold is applied to the muscle.

Previous research has suggested that local cryo-stimulation inhibits spinal excitability [1] and reduces the nerve conduction velocity. In theory, inhibited activity of muscle spindles and afferent fibres would inhibit muscle activation during its lengthening allowing more stretch at a given load. It is known that body temperature after WBC remains reduced for up to 30 min after the exposure. Reduced neural activity due to cryo-stimulation supports the findings from the present study that ROM is increased immediately after WBC.

An interesting observation from the present study is a slight, but

statistically significant increase in ROM for women in the control group. Women are known for being more prone to acute effects of stretching on ROM than men [6]. There is a possibility that the effect of the baseline sit-and-reach test would interfere with the results during the post measurements. However, when taking into account the relative difference from baseline and comparison to the WBC group, we see that the change in the control group is a lot smaller than the change in the WBC group.

In summary, our results support the hypothesis that ROM is increased immediately after a single session of WBC. This is of practical value for practitioners working with symptomatic and non-symptomatic clientele aiming to increase ROM. Further research to understand the underlying mechanisms of this phenomenon is warranted.

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