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# EFFECTS OF CRYOTHERAPY ON LOWER EXTREMITY JOINT BIOMECHANICS DURING RUNNING.

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## INTRODUCTION

Cryotherapy is widely employed as a conservative intervention for acute and chronic injuries in patients and athletes. Reduction of pain, edema and inflammation, as well as muscle spasm relief and movement facilitation are some of the benefits of cryotherapy [1]. However, potentially negative effects have also been reported such as a decrease in fiber conduction velocity whereby the proprioception input may be altered [2]. Hence, athletic performance after cryotherapy may also be affected [3].

Despite the lack of conclusive findings on the effects of cryotherapy on movement patterns, it has still been widely used by clinicians in the treatment of acute soft tissue injury [4]. However, changes in proprioception have been reported as an advised caution when individuals are returning to competition immediately after cooling [5]. In the current literature, the possible detrimental effects of cryotherapy on athletic movement patterns prior to exercise are still unclear.

Therefore, the purpose of this study was to compare running gait mechanics pre- and post-cryotherapy to better understand its effects on the vertical (VGRF), anterior-posterior ground reaction force (braking and propulsive forces) and on the ankle and knee joint moments in all anatomical planes. In addition, contact time was also quantified to analyze if performance would also be affected. We hypothesized that cryotherapy would increase the loading on lower extremity joints during running and that the performance would be altered due to possible changes in proprioception.

## METHODS

Twenty six males (age: 24.8 ± 3.9 years; height: 177.1 ± 8.2 cm; mass: 71.3 ± 8.2 kg;) volunteered to participate in this study and were randomly allocated to either an intervention group or control group. All subjects were free of any lower extremity injury in the last 6 months, and were recreationally active. Prior to the test, a consent form was given and signed by each participant.

This study consisted of two parts: pre and post-intervention. Prior to the intervention, a neutral standing calibration trial was performed where a triad of retro-reflective markers was attached on the right foot (shoe), shank, thigh, and on the pelvis of each subject. Additionally, anatomical markers on the medial and lateral malleolus, medial and lateral epicondyles of the femur, and greater trochanter were attached to define the location of the joint centers. Then, the anatomical markers were removed, and the subjects were asked to perform seven running trials at 4m/s. Eight Motion Analysis infrared cameras (Motion Analysis Corp., Santa Rosa, CA) recorded the 3D positions of each marker at 240 Hz. Additionally, a force plate (Kistler AG, Winterhur, Switzerland) embedded in the floor collected the ground reaction force at 2400 Hz. After the baseline data collection, each subject was randomly assigned to either the intervention group (cold water at ~ 11ºC) or control group (non-cold water at ~ 26ºC). They were asked to remain sitting in the water tub for 20 minutes, immersed in the water up to the umbilical level. Following the intervention, data collection procedures were repeated to determine the effect of the intervention.

Kinematic and kinetic data were analyzed using an inverse dynamics approach with Kintrak 7.0 software (Motion Analysis Corp., Santa Rosa, CA) and filtered using a fourth-order low-pass Butterworth filter with cut-off frequency of 8 Hz and 50 Hz, respectively. Peak VGRF, braking and propulsive forces, ankle and knee moments in the sagittal, frontal and transverse plane were calculated. The contact time during running was also measured.

The discrete variables were extracted from each trial and then averaged across trial to obtain the subject's pattern. A 2x2 mixed factorial ANOVA with group (Control and Ice) as between factor and time (Pre- and Post-) as within factor were computed. An alpha of 0.05 was used for all statistical tests executed in R software (version 2.15.1).

## RESULTS AND DISCUSSION

ANOVA revealed a main effect of time for the peak VGRF ($F(1,24)=8.617$; $p<0.01$), with significant interaction ($F(1,24)=4.948$; $p=0.03$), where the peak VGRF decreased following cryotherapy ($p=0.01$). For the braking force, a main effect of time was observed ($F(1,24)=4.684$; $p=0.04$), with higher braking force after cryotherapy ($p<0.01$). The propulsive force presented an ANOVA main effect of time ($F(1,24)=19.31$; $p<0.01$), and a significant interaction ($F(1,24)=8.98$; $p<0.01$), where a lower force was found in the ice group ($p<0.01$) (Figure 1). Additionally, the contact time presented an ANOVA main effect of time ($F(1,24)=4.345$; $p=0.04$) and significant interaction ($F(1,24)=5.079$; $p=0.03$), where following cryotherapy, a higher contact time was detected ($p=0.02$) (Figure 1).

With regard to the joint moments, ANOVA revealed a main effect of time for the plantarflexion moment in the ice group ($p$<0.01). No differences were found for the peak knee joint moments, ankle dorsiflexion, inversion and abduction moments (Figure 2).

Immediately after cryotherapy, higher braking and lower propulsive forces were found compared with the control group. A previous study reported that velocity may decrease if the propulsive force diminishes [6]. In fact, after intervention, the contact time for the ice group was higher compared with the control group. Patterson et al [3] also described that the time to complete various running-based agility tests was longer following 10-20 minutes of lower limb icing.

Despite the potential negative effects in proprioception after cryotherapy [2], the knee and ankle joint loading remained unaltered following cold water therapy. It is possible that the subjects used different kinematic strategies, and due to the changes in proprioception, they possibly adopted a different gait pattern avoiding excessive loading in the joints following cryotherapy.

## CONCLUSIONS

This study suggests that cryotherapy can be used as a form of intervention in patients and athletes without increase in joint loading. However, changes in the anterior-posterior ground reaction forces and contact time may negatively affect the functional performance of individuals in athletic activities, particularly running. Thus, cryotherapy should be prescribed with caution prior to exercise and its effects on lower extremity biomechanics need to be further investigated.

## ACKNOWLEDGEMENTS

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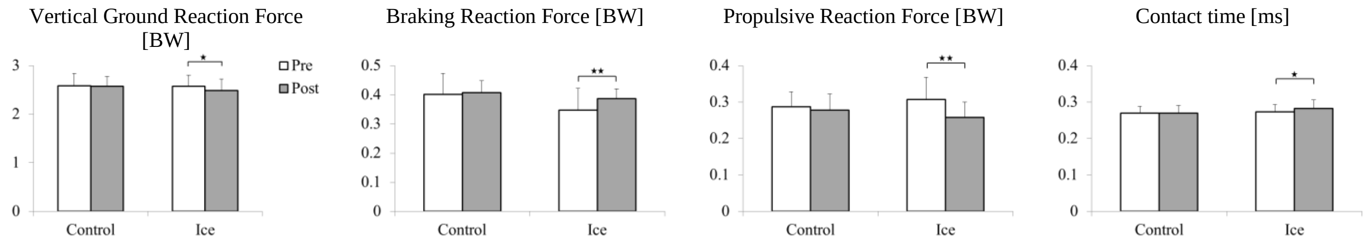


**Figure 1.** The average values of the vertical, braking and propulsive reaction force, and contact time across subjects. Error bars indicate the standard deviation of the means. Significant differences are represents by *$p$<0.05; **$p$<0.01.

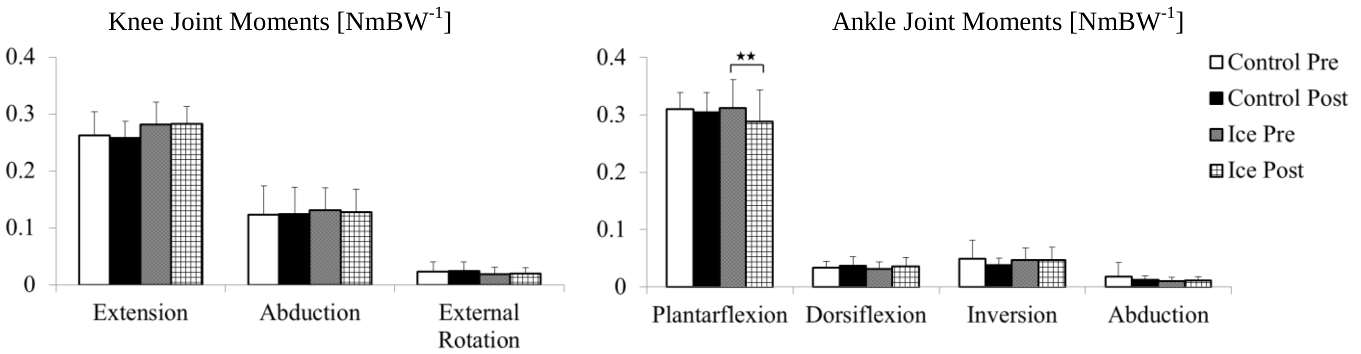


**Figure 2.** The average values of the knee and ankle moments in the sagittal, frontal, and transverse plane across subjects. Error bars indicate standard deviation of the means. Significant differences are represents by *$p$<0.05; **$p$>0.01.