DELAYED EFFECTS OF A 20 MINUTE CRUSHED ICE APPLICATION ON KNEE JOINT POSITION SENSE DURING A FUNCTIONAL TASK

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Background

A common practice within clinical and sporting populations for the management of soft tissue injury, cryotherapy is known to induce a multitude of physiological changes (1,2). Reductions in oedema, nerve conduction velocity (3), and tissue metabolism are reported (4,5,6) in addition to changes in joint position sense (JPS) and proprioception (7,8); with exploratory studies demonstrating immediate effects of cryotherapy application on knee joint repositioning, it is the 'latent' or 'delayed' effects on JPS at the knee however, that are under contention in the literature (7).

Non-invasive infrared thermal imaging (TI) cameras serve as an accurate method of quantifying skin surface temperature (T_{sk}) (9,2,10,11). T_{sk} therapeutic range can be observed using TI, following cryotherapeutic application. A relationship is apparent between T_{sk} and intramuscular temperature (T_{im}) cooling whereby a quadratic association occurs (12). T_{im} continues to cool whilst T_{sk} re-warms and therefore poses consideration into the effect on muscle spindle activity and changes in neuromuscular feedback.

Commonly athletes in contact sports, return to the field of play following short cryotherapy applications (1,7). Previous literature proposes an increased risk of injury, with immediate adverse adaptations occurring from physiological variations affecting knee joint mechanics following 20 minute exposure of crushed ice at the knee (7). The current study therefore investigated the effects of a 20-minute application of crushed ice at the knee on JPS, over a re-warming period of up to 20-minutes post removal.

Purpose

An earlier exploratory study by Alexander et al (2015) presented changes in the ability to reproduce accurately knee joint position in the sagittal and coronal planes immediately post cryotherapy intervention. It is unknown as to whether noted effects reported in the literature continue longer than only immediately post removal of crushed ice. The significance of the continuation of T_{im} cooling whilst T_{sk} re-warms, may therefore pose consideration into the effect on muscle spindle activity and changes in neuromuscular feedback during a 're-warming' period post cryotherapy removal.

Material and Methods

17 healthy male participants took part in the study performing a functional task (21.8 ± 3.5 years, 81.1 ± 16.5 kg and 177.9 ± 7.9 cm). Using three-dimensional motion analysis (Qualisys Medical AB Gothenburg, Sweden) (Figure 1. (A,B)), kinematics of the knee was measured during a weight bearing functional task (small knee bend) pre and immediately post, 5, 10, 15 and 20 minutes' cryotherapy intervention. The target angle of 45° was held for 5s supporting previous methodologies (2,7,13) and limb position awareness (8) (Figure 1. (C).

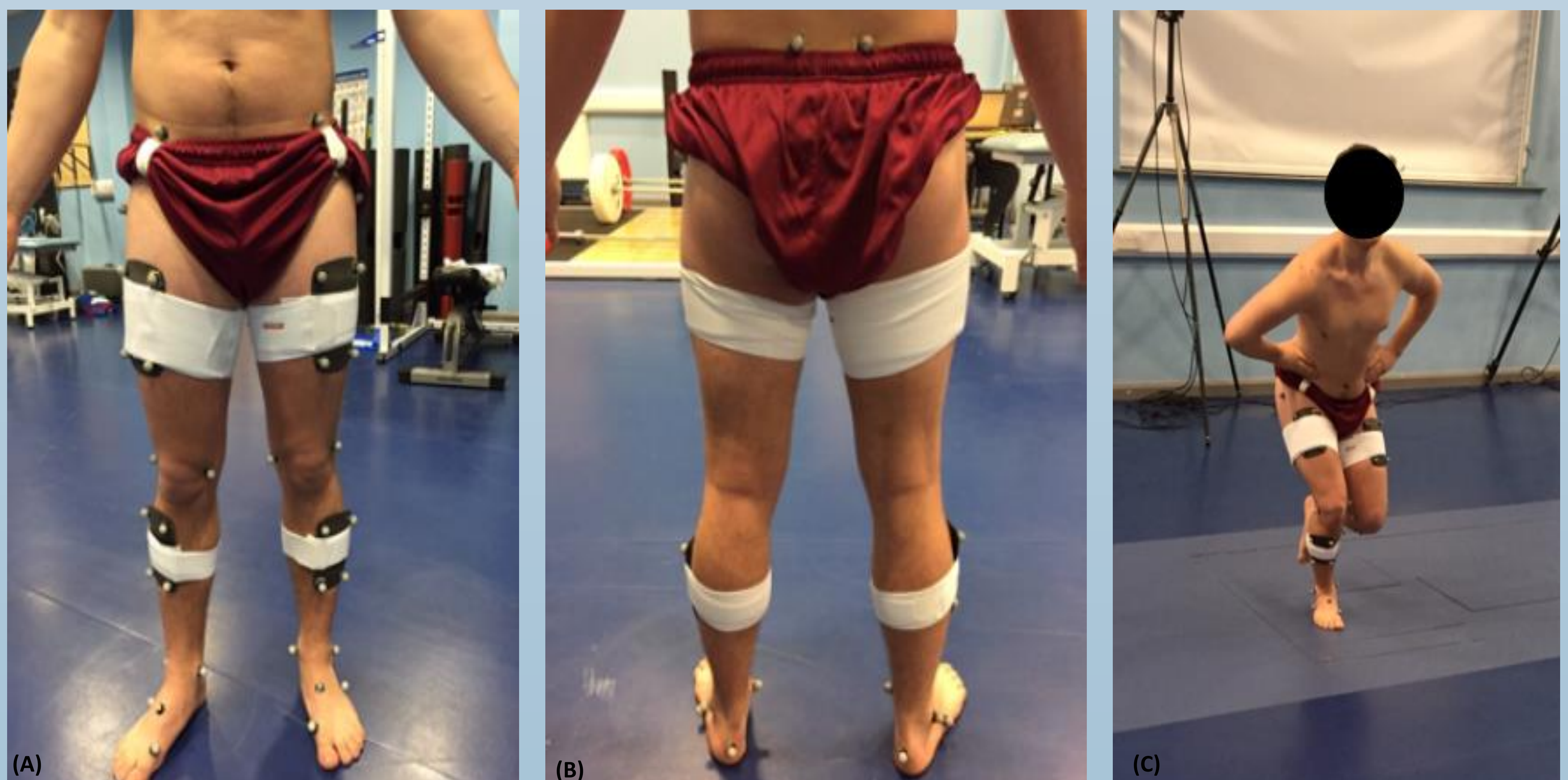

Figure 1. (A) Anterior and posterior (B) view of the lower limb marker and cluster placement using the CAST marker set. (C) Functional task of a small knee bend pre intervention.

T_{sk} was measured via infrared non-contact thermal imaging (Flir Systems, Danderyd, Sweden) over the anterior and medial aspect of the knee. Region of interest (ROI) were determined by the application of four wooden markers applied to the apex and base of the patella and medial and lateral joint lines (Figure 2. (A)).

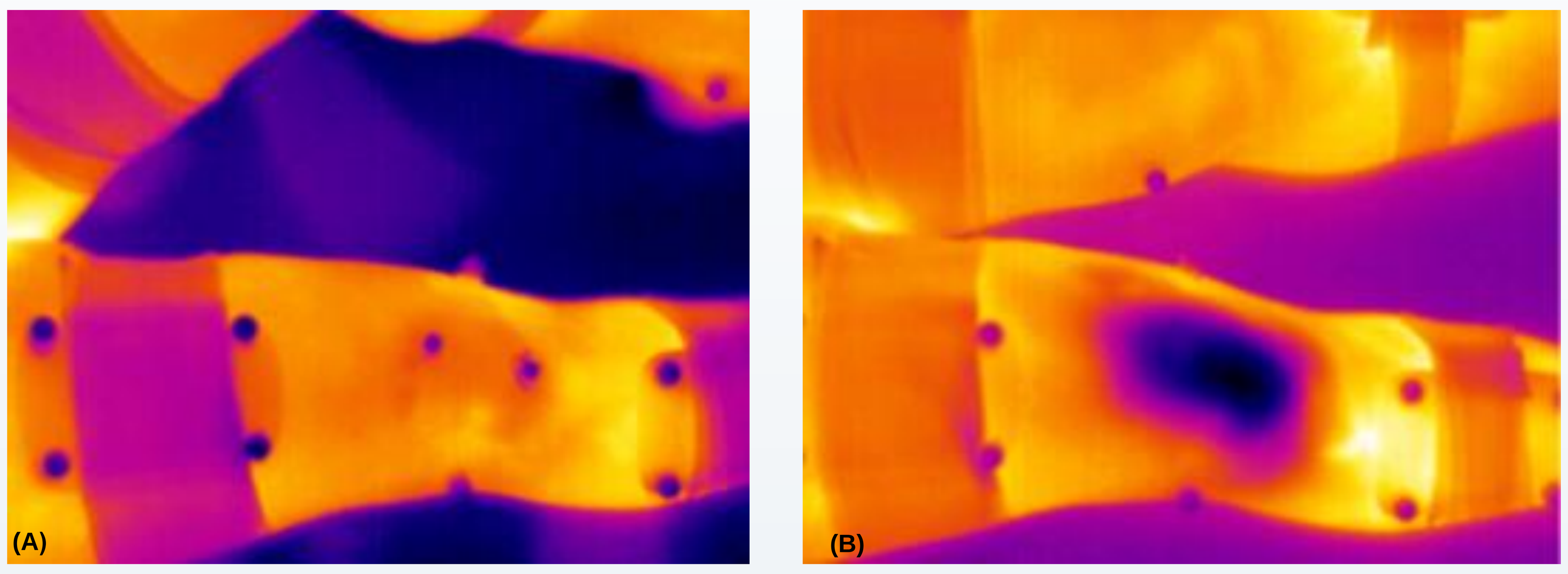

Figure 2. (A) Thermal image of non-dominant lower limb with ROI marker set up, pre intervention. (B) Thermal image for non-dominant knee 20 minutes post cryotherapy removal.

Results

Significant decreases (P=<0.05) in T_{sk} were reported for both ROIA and ROIB, with ROIA (patella) region, meeting the expected therapeutic range for an analgesic response Figure 2 (B). Results demonstrated significant reductions in the ability to accurately replicate knee joint positioning. A significant increase (P=>0.05) in rotational movement in the transverse plane occurred 20 minutes' post intervention removal

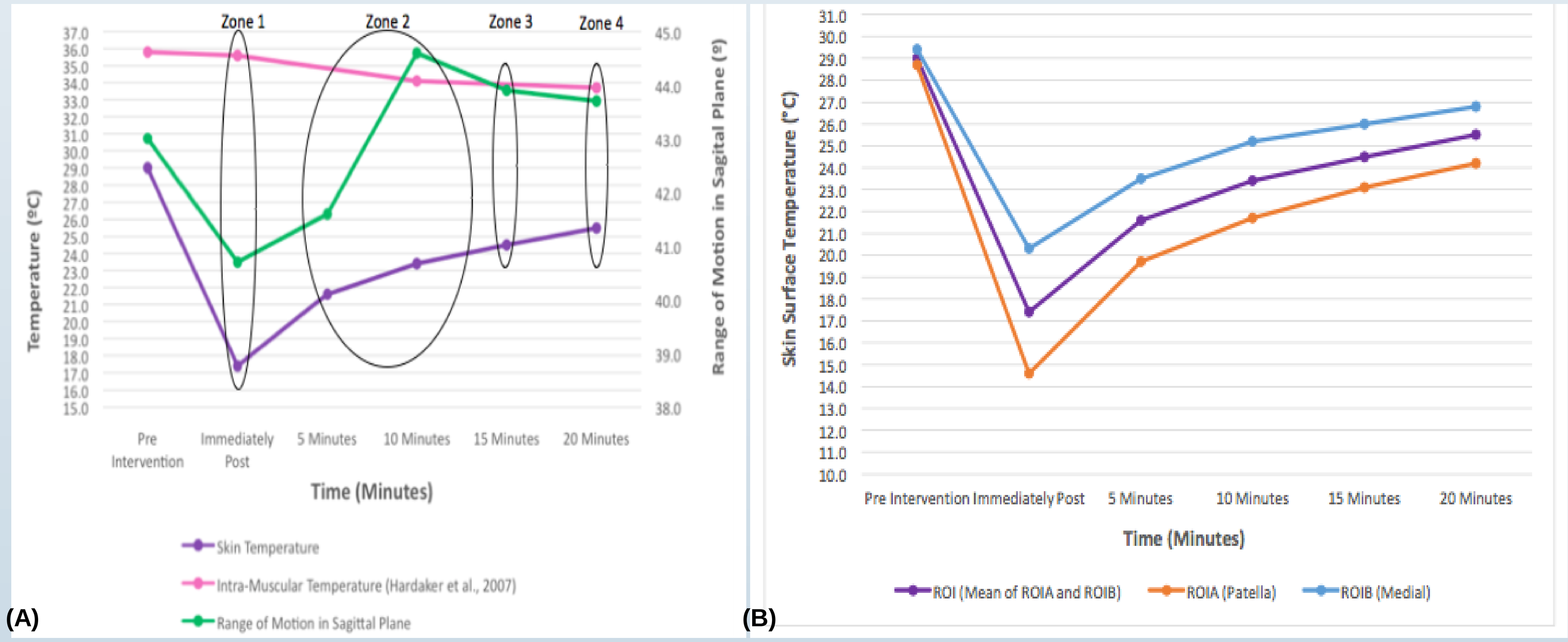

Figure 3 (A). T_{sk} **ROM in the sagittal plane and** T_{im} **adapted from Hardaker *et al.* (2007). Presenting the relationship between three sets of data, pre to 20 minutes post intervention and highlighting four 'zones' of interest. (B)** T_{sk} **for ROIA and ROIB individually and combined.**

Discussion

A 20-minute application of crushed ice to the anterior aspect of the non-dominant knee induced adverse responses in knee JPS, 20 minutes after ice was removed. Although at 20 minutes post cryotherapy intervention, participants were able to replicate the target angle of 45°, a significant reduction in rotational control was reported. It is unknown as to whether the delayed effects on knee joint repositioning and dynamic stability occurred in relation to JPS or neuromuscular adaptations. The known relationship between T_{sk} and T_{im} (12), could postulate a change in neuromuscular response to cold occurred.

Research suggests deeper regions of the sensorimotor system within a joint are not affected by the application of cryotherapy (14). Wassinger et al, (2007) (15) assumed that deeper mechanoreceptors were able to compensate for receptors affected by cryotherapy at a superficial level. The current study proposes that deeper sensorimotor mechanisms are affected through the T_{im} response during a 're-warming' period, such as proprioceptive feedback caused by decreases in NCV from cryotherapy (16). As T_{sk} re-warms we assume T_{im} continued to cool and the increase in rotational motion at the knee occurred due to delayed intramuscular and ligamentous cooling at 20 minutes' post cryotherapy intervention, affecting proprioceptive mechanisms.

The current study proposes that a synthesis occurs between T_{sk} ROM/JPS and T_{im} (Figure 3), explaining the changes in knee joint stability. A decrease in rotational stability at the knee is a common mechanism or movement pattern for injury at the knee. It may be suggested there is a risk of injury at 20 minutes' post cryotherapy removal through altered mechanoreceptor feedback through reduced proprioceptive control.

Conclusion

These postulations should be considered by therapists for athletes returning to functional activities or the field of play following cryotherapy exposures at the knee, with an increase in susceptibility for injury with rotational ROM control increasing during a SKB 20 minutes post removal of cryotherapeutic application. Functional movements including full WB rotational activities therefore may be considered inappropriate following this method of intervention due to the increased risk of injury.

References

(1) Bleakley, et al (2012); (2) Costello et al, (2012); (3) Jutte et al, (2001); (4) Bugaj, (1975); (5) Knight, (1989); (6) Topp et al, (2013); (7) Alexander et al, (2015); (8) Costello and Donnelly, (2010); (9) Merrick et al, (2003); (10) Costello et al, (2013); (11) McFarlin et al, (2015); (12) Hardaker et al, (2007); (13) Mohammadi, Taghizdeh, Ghaffarinejad, Khorrami and Sobhani, (2008); (14) Khanmohammadi et al, (2011); (15) Wassinger et al, (2007); (16) Uchio et al, (2003)