Physical Therapy in Sport 18 (2016) 21–26

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

An exploratory study into the effects of a 20 minute crushed ice application on knee joint position sense during a small knee bend

Jill Alexander*, James Selfe, Ben Oliver, Daniel Mee, Alexandra Carter, Michelle Scott, Jim Richards, Karen May

University of Central Lancashire, Allied Health Professions Research Unit, Brook Building, Preston, Lancashire PR1 2HE, United Kingdom

A R T I C L E I N F O

Article history:
Received 15 July 2014
Received in revised form
19 May 2015
Accepted 9 June 2015

Keywords:
Cryotherapy
Knee
Kinematics
Joint position sense

A B S T R A C T

Objectives: The effect of cryotherapy on joint positioning presents conflicting debates as to whether individuals are at an increased risk of injury when returning to play or activity immediately following cryotherapy application at the knee. The aim of this study was to investigate whether a 20 min application of crushed ice at the knee immediately affects knee joint position sense during a small knee bend.
Design: Pre- and post-intervention.
Setting: University movement analysis laboratory.
Participants: Eleven healthy male participants.
Main outcome measures: Kinematics of the knee were measured during a weight bearing functional task pre and post cryotherapy intervention using three-dimensional motion analysis (Qualisys Medical AB Gothenburg, Sweden). Tissue cooling was measured via a digital thermometer at the knee.
Results: Results demonstrated significant reductions in the ability to accurately replicate knee joint positioning in both sagittal ($P = .035$) and coronal ($P = .011$) planes during the descent phase of a small knee bend following cryotherapy.
Conclusion: In conclusion a 20 min application of crushed ice to the knee has an adverse effect on knee joint repositioning. Team doctors, clinicians, therapists and athletes should consider these findings when deciding to return an athlete to functional weight bearing tasks immediately following ice application at the knee, due to the potential increase risk of injury.

1. Introduction

The application of ice for the treatment of soft tissue injuries is common practice within sport and clinical settings (Bleakley, Costello, & Glasgow, 2012; Bleakley, McDonough, & MacAuley, 2004; Costello & Donnelly, 2011). Cryotherapy in this instance is generally applied to provide cold induced analgesia by aiming to reduce tissue temperatures to 13.6 °C (Bleakley et al., 2012; Bugaj, 1975; Jutte, Merrick, Ingersoll, & Edwards, 2001) in order for physiological changes to occur (Algafly & George, 2007; Fishman, Ballantyne, Rathmell, & Bonica, 2010; Knight & Draper, 2013; Nadler, Weingand, & Kruse, 2004; Rice, McNair, & Dalbeth, 2009). It has been previously established that cellular metabolism is reduced by 10% when skin surface temperatures (Tsk) are between 10 and 11 °C (Bugaj, 1975). Other research suggests a reduction in nerve conduction velocity (NVC) occurs at 12.5 °C (Jutte et al., 2001), and hypometabolism onset at 15 °C (Knight & Draper, 2013). Algafly and George (2007) reported a 33% reduction in nerve conduction velocity (NCV) when Tsk was cooled to 10°, supporting earlier work by Chesterton, Foster, and Ross (2002). Kennett, Hardaker, Hobbs, and Selfe (2007) suggest Tsk between 10 °C and 15 °C can therefore define an optimum therapeutic Tsk range. It is interesting that although the effects of cryotherapy on proprioception and joint position sense (JPS) are largely unknown (Costello & Donnelly, 2010), clinicians and therapists continue to apply cold modalities such as ice in a clinical or pitch side setting (Bleakley et al., 2011). Anecdotal evidence suggests that ice is applied during rehabilitation to facilitate joint movement. Athletes therefore often perform exercises immediately after cryotherapy. There is however, little consensus in the literature on how functional performance and joint range of movement is affected by the application of cold, with recent systematic reviews (Bleakley et al., 2012; Bleakley & Costello, 2013) reporting varying conclusions.

* Corresponding author. Tel.: +44 1772 892781.
E-mail address: JAlexander3@uclan.ac.uk (J. Alexander).

http://dx.doi.org/10.1016/j.ptsp.2015.06.004
1466-853X/

In sport poor JPS has been associated with functional instability and increased risk of knee injury thought to be caused by increases in postural sway, balance deterioration and disturbances to gait patterns (Kiran, Carlson, Medrano, & Smith, 2010). Although it is still undecided as to how JPS reduces due to cryotherapy applications and the implications it may have on the risk of injury, due to potential changes in functional stability. Assessment of joint position can influence clinical practice, with therapeutic interventions known to affect dynamic stability (Williams et al., 2001) it is recommended that active angle reproduction (AAR) should be used as a method of assessment for knee JPS (Selfe et al., 2006). Accuracy of the ability to reproduce a joint angle is affected by the type of test applied, during AAR quicker positional stabilisation was accomplished compared to passive angle reproduction (PAR) (Selfe et al., 2006). The application of active reproduction tests in the current study closely mimics functional performance in athletes, supporting previous research (Bennell et al., 2005; Stillman, 2002).

The reliability of previous research around JPS and cryotherapy application is debatable; Surenkok, Aytar, Tuzun, and Akman (2008) found that knee JPS was negatively affected following both the application of a cold pad and post application of a cold spray using a passive knee repositioning test. Neither Tsk nor duration of cold pad or cold spray was reported. Thieme, Ingersoll, Knight, and Ozmun (1996) reported no significant difference in active movement reproductions following a 20 min application of an ice pack to the knee compared to the control of no ice pack. The use of the most accurate trial instead of mean error in this study has been questioned as trials that produced a less accurate angle were disregarded (Costello & Donnelly, 2010). Alternatively a recent systematic review by Bleakley et al. (2012) suggested that a negative effect on functional performance occurs after 20 min cryotherapy application. In addition, Ribeiro et al. (2013) support the recommendation that cryotherapy has a damaging effect on proprioception at the knee. Functional impairments in JPS at the knee were also reported by Watanabe et al. (2013) following a cryotherapy application time of 15 min. Studies on the ankle (Hopper, Whittington, & Davis, 1997; La Riviere & Osternig, 1994) and the shoulder (Dover & Powers, 2004; Wassinger, Myers, Gatti, Conley, & Lephart, 2007) have also shown conflicting results. Reductions in JPS are commonly assessed clinically to identify proprioceptive deficits these may indicate that an individual is at risk of injury (Bleakley, McDonough, & MacAuley, 2006; Costello & Donnelly, 2010; Surenkok et al., 2008; Uchio, Ochi, Fujihara, Adichi, Iwasa, & Sakai, 2003; Wassinger et al., 2007; Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007). It is supported by Whatman, Hume, and Hing (2013) that the SKB lower extremity functional test is a useful tool in clinical decision making concerning risk of injury and dynamic alignment of the lower limb. Literature fails to agree whether it is safe to return athletes to dynamic functional tasks immediately following the application of ice to the knee. This study therefore examines the effects of crushed ice application to the knee using a small knee bend (SKB) as a functional assessment to observe knee JPS.

2. Methods

2.1. Participants

This exploratory study included eleven healthy male volunteers who regularly participate in team, land based sports took part in the study, with an average age of 21.3 ± 1.7 years, body mass of 83.5 ± 32.5 kg and height of 182 ± 12.8 cm. All participants provided written consent to take part in the study. The study was conducted according to the Declaration of Helsinki (WMA, 2008) and approved by UCLan Built, Sport and Health Ethics Committee (BuSH 128). All male participation was chosen to increase sample homogeneity due to gender differences found in response to local cooling (Cankar & Finderle, 2003). Criteria for exclusion from the study included previous knee joint surgery, lower limb injury in the last 6 months, referred pain either to or from the knee or any contraindications to cryotherapy (Kennett et al., 2007).

2.2. Intervention protocol

The study was a single group, pre-test–post-test design. The testing protocol took place in a movement analysis laboratory. Kinematic data were collected pre- and post-intervention using a ten camera infra-red Oqus motion analysis system (Qualisys medical AB, Gothenburg, Sweden) collecting at 115 Hz. Cameras were arranged in an umbrella formation (Richards, 2008). Participants acclimatised to a steady thermal state for a 15 min period, prior to intervention; during this phase passive retro-reflective markers were placed on the following anatomical landmarks (Fig. 1); posterior superior iliac spine (PSIS), anterior superior iliac spine (ASIS), greater trochanter, medial and lateral epicondyle of the femur, medial and lateral malleolus, calcaneus, dorsal aspect of first and fifth metatarsal heads and the middle cuneiform, acromion, lateral epicondyle of the humerus and radial styloids. Clusters of four markers mounted on a thin sheath of lightweight carbon fibre were applied to the anterolateral aspect of the femur and tibia. Three measures of Tsk were taken from the centre of participants' patella following the acclimatisation period, using a digital thermometer (Fora, Gallen, Switzerland IR19). The accuracy of the skin surface thermometer meets the accuracy required in ASTM E1965-98 and the EC directive 93/42/EEC.

Pre-testing, familiarisation to the SKB protocol of 45° was conducted measured by a goniometer, prior to kinematic data collection. The participant was given three attempts to replicate the 45° SKB in order to familiarise themselves with the movement pattern (Reurink et al., 2013). Following the 'practice' attempts participants then completed five SKB using three dimensional (3D) motion analyses to measure knee motion. No white noise or blindfolds were worn by the participants; it was felt that by removing sensory cues the eco-validity of the study would be inhibited, an athlete returning to sport immediately following the application of ice would not usually have sensory cues removed. The methodology in the current study uses an active target angle of 45°. This supports similar research by Olsson, Lund, Henrikson, Rogind, Biddal, and Danneskoid-Samsoe (2004) that suggests knee JPS test angles should be between 40° and 80° flexion when assessing SKB. Each repetition of the SKB was held at a target angle of 45° for 5 s. Literature supports a 5 s hold (Costello, Algar, & Donnelly, 2012; Mohammadi, Taghizadeh, Ghaffarinejad, Khorrami, & Sobhani, 2008; Olsson et al., 2004), suggesting that this allows for awareness of limb position (Costello & Donnelly, 2011). Testing was carried out on the participant's non-dominant leg, shown to be the most likely for knee injury to occur, in contact and non-contact sports (Krajnc, Vogrin, Recnik, Crnjac, Drobnic, & Antolic, 2010; Ruedl et al., 2012; Vauhnik, Morrissey, Rutherford, Turk, Pilih, & Pohar, 2008). The dominant leg was determined by which leg they would normally kick a ball with to ensure the non-dominant leg was established (Surenkok et al., 2008).

Two anatomical markers were removed from the medial and lateral epicondyles of the knee prior to 800 g of crushed ice contained in a clear plastic bag applied over the anterior aspect of the non-dominant knee. The aim of this application was to achieve a Tsk of between 10 and 15 °C. The bag of ice was covered by a damp single microfiber towel held in place by cling film wrap, for the clinically relevant time of 20 min (Janwantanakul, 2009; Kennet et al., 2007; Owens, Hart, Donofrio, Haralabous, & Miezejewski, 2004).