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Original article

Effects of superficial heating and insulation on walking speed in people with hereditary and spontaneous spastic paraparesis: A randomised crossover study

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ABSTRACT

Objectives: Cooling of the lower limb in people with Hereditary and Spontaneous Spastic Paraparesis (pwHSSP) has been shown to affect walking speed and neuromuscular impairments. The investigation of practical strategies, which may help to alleviate these problems is important. The potential of superficial heat to improve walking speed has not been explored in pwHSSP. Primary objective was to explore whether the application of superficial heat (hot packs) to lower limbs in pwHSSP improves walking speed. Secondary objective was to explore whether wearing insulation after heating would prolong any benefits.

Methods: A randomised crossover study design with 21 pwHSSP. On two separate occasions two hot packs and an insulating wrap (Neo-G^{TM}) were applied for 30 minutes to the lower limbs of pwHSSP. On one occasion the insulating wrap was maintained for a further 30 minutes and on the other occasion it was removed. Measures of temperature (skin, room and core), walking speed (10 metre timed walk) and co-ordination (foot tap time) were taken at baseline (T1), after 30 mins (T2) and at one hour (T3).

Results: All 21 pwHSSP reported increased lower limb stiffness and decreased walking ability when their legs were cold. After thirty minutes of heating, improvements were seen in walking speed (12.2%, $P < 0.0001$, effect size 0.18) and foot tap time (21.5%, $P < 0.0001$, effect size 0.59). Continuing to wear insulation for a further 30 minutes gave no additional benefit; with significant improvements in walking speed maintained at one hour (9.9%, $P > 0.001$) in both conditions.

Conclusions: Application of 30 minutes superficial heating moderately improved walking speed in pwHSSP with effects maintained at 1 hour. The use of hot packs applied to lower limbs should be the focus of further research for the clinical management of pwHSSP who report increased stiffness of limbs in cold weather and do not have sensory deficits.

1. Introduction

Hereditary and spontaneous spastic paraparesis are progressive neurological disorders with key symptoms of spasticity and weakness observed [1,2]. These symptoms which are worse distally reflect the degeneration of central tracts within the spinal cord (corticospinal, spinocerebellar and dorsal columns) [1]. People with Hereditary and Spontaneous Spastic Paraparesis (pwHSSP) who have complicated presentations report additional signs and symptoms such as dementia or epilepsy [2] No objective difference is observed in the gait pattern of people with different presentations of HSSP [3]. Whilst health care services, such as pharmacological interventions and physiotherapy can provide some benefit, access to these are often limited [4] and hence exploring practical self-management options that pwHSSP can undertake for themselves, and incorporate into their daily lives, is important. Focus groups of pwHSSP ($n = 36$, unpublished observations) highlight that many experience slower walking and that their legs feel stiffer in cold weather, which can cause them to limit their activities. The participants reported that in cold weather they often choose to increase layers of clothing to insulate their legs because they feel that this helps to relieve the leg stiffness and ease their walking difficulties.

Previous studies have demonstrated thermal effects on nerve conduction velocity and muscle spindle excitability [5–8]. In

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pwHSSP and controls, a laboratory based study [9] explored the effects of superficial cooling and heating using a constant temperature wrap controlled by a water bath, demonstrating that cooling of the lower limb decreased walking speed. In both groups, superficial cooling had a negative effect on neuromuscular function; with a slower foot tap time, reduced rate of force generation (dorsiflexor muscles), reduced peripheral nerve conduction speed, and an increased stretch reflex size after 30 minutes in the targeted limb. In contrast, superficial warming of one lower limb increased the rate and amplitude of force generation (dorsiflexor muscle), tibial nerve conduction velocity and decreased the size of the stretch reflex. However, despite the improvements in these neuromuscular parameters no improvement in walking speed was observed in either group. It was postulated that this lack of significant improvement in walking speed with warming may be related to the fact that only the plantar and dorsiflexor muscles on one leg was heated, whilst walking is a bilateral task involving multiple muscle groups. Further, the method of warming, using a temperature controlled water bath pumping water around a cuff surrounding the shank would not be practical in a real-world setting. The results and limitations suggested that bilateral superficial heating to increase lower limb temperature should be further evaluated in pwHSSP using a more portable system, which is feasible for implementation by people within their daily lives, such as commercially available hot packs.

Passive warm up using external application of heat to increase temperatures of neuromuscular structures below the skin has been part of the physiotherapy toolbox for many years [10]. Modalities of heating can be divided into superficial and deep heating; superficial heating is provided by means such as hot packs and deep heating by modalities such as ultrasound or shortwave diathermy. Hot packs have been used as a management strategy by physiotherapists for a variety of musculoskeletal conditions including pain management [11,12] as well as by athletes as part of warm up and stretching protocols [13]. In people with neurological conditions, hot packs have been used for the management of chronic pain in people with spinal cord injury [14] but care is advised when sensory and/or circulatory deficits are evident to reduce the risk of burns [12].

The size and shape of a limb and the level of adipose tissue may affect the thermal dose achieved and should therefore be considered as an important variable when comparing effects across participants [15].

Research in the field of sports science suggests that the use of insulating garments may help to prolong any increase in skin and muscle temperature achieved with active exercise. For example, insulated track shorts have been shown to maintain temperature increases [16] in cyclists, whilst in rugby players the use of an insulated jacket has been shown to maintain core body temperature and maintain peak performance output [17].

The primary objective of this study was to explore whether 30 minutes superficial heating of the dorsiflexor and plantarflexor muscles of both lower limbs, using commercially available hot packs, would translate to improvements in walking speed in pwHSSP. The secondary objective was to explore whether the use of insulation would maintain any benefits in walking speed.

2. Materials and methods

2.1. Study design

This was an unblinded randomised cross over study design, undertaken within a university laboratory setting.

2.2. Participants

Twenty-one pwHSSP participated in the study. With 21 pwHSSP we can detect an effect size of 0.63 ($\alpha = 0.05$, power = 0.8) based on previous data in pwHSSP [9]. This equates to a change in speed of 0.26 m/s, which is above the minimal clinically important difference in walking speed in people with stroke (0.1–0.2) [18]. Volunteers were recruited by responding to an advert in the UK HSP Support group quarterly newsletter. Participants were included if they:

- had a diagnosis of spastic paraparesis;
- spasticity, graded at least one on the Ashworth Scale in both of their lower limbs;
- were able to independently walk at least 20 m with/without a walking aid.

People were excluded if they had:

- additional orthopaedic/neurological impairments;
- poor skin integrity, or reduced sensation;
- fixed ankle inversion contracture;
- scored ≥ 6 on the Abbreviated Mental Test Score [19] as an indicator of those whose cognitive difficulties could interfere with the consent process or study procedures.

2.3. Data collection procedures

After providing written consent, participant's baseline characteristics (height, weight, age, gender, family history, length of symptoms, additional signs and symptoms, use of anti-spasticity medication and perceived impact of temperature on walking) were recorded. The Ashworth Score was undertaken to categorise severity of spasticity in the plantarflexor muscles [20]. People were classified as pure or complicated presentations according to genetic diagnosis and or the presentation of complicating signs and symptoms [2]. The Abbreviated Mental Test Score was used to evaluate whether additional signs of dementia were present for classification. A self-report Barthel Index recorded functional ability [21]. Walking Index for Spinal Cord Injury II (WISCI II) recorded functional walking ability [22] Skin fold thickness overlying the ankle plantarflexor muscles was measured using a Harpenden Skinfold Caliper™, (Baty International, UK) at the level of the midshank [15]. BMI was calculated from height and mass [23]. Temperature sensitivity was established by asking participants whether they experienced changes in their walking abilities in cold or warm temperatures and a yes/no response recorded.

2.4. Intervention

Participants attended two separate sessions, at least 24 hours apart. At each session two 26 × 13 cm diameter, gel-filled hot packs (Neo-G™ UK) were heated in a constant temperature water bath at 45°C for a minimum of 20 minutes. Participants were seated in a supported position, whilst the hot packs were applied to the front and back of each of the participants' shanks over tibialis anterior and gastrocnemius muscles and held in place with insulating neoprene based calf wraps (Neo-G™, UK, Fig. 1). The hot packs and insulating wraps were left in place for 30 minutes, during which time the skin was visually inspected by the researcher at 5 minutes and 15 minutes. Participants were asked to report on their levels of comfort throughout.

At each session the hot packs were removed after 30 minutes heating. On one visit the insulating wraps were kept in place for an additional 30 minutes (termed insulation) and on the second visit

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