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Effect of burst TENS and conventional TENS combined with cryotherapy on pressure pain threshold: randomised, controlled, clinical trial

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Abstract

Objective To assess the immediate effect of conventional and burst transcutaneous electrical nerve stimulation (TENS) in combination with cryotherapy on pain threshold and tolerance in healthy individuals.
Design Randomised, controlled trial.
Setting University laboratory.
Participants One hundred and twelve healthy women.
Interventions Volunteers were allocated at random to seven groups ($n = 16$): (1) control, (2) placebo TENS, (3) conventional TENS, (4) burst TENS, (5) cryotherapy, (6) cryotherapy in combination with burst TENS, and (7) cryotherapy in combination with conventional TENS. Pain threshold and tolerance were measured by applying a pressure algometer at the lateral epicondyle of the humerus, before and after each intervention.
Main outcome measures The primary outcome measure was pressure pain threshold.
Results A significant increase in pain threshold and tolerance at the 5% level of significance was recorded as follows: burst TENS {pain threshold: mean difference 1.3 [95% confidence interval (CI) 1.4 to 1.2]; pain tolerance: mean difference 3.8 (95% CI 3.9 to 3.7)}, cryotherapy [pain threshold: mean difference 1.3 (95% CI 1.4 to 1.2); pain tolerance: mean difference 1.9 (95% CI 1.8 to 2.0)] and cryotherapy in combination with burst TENS [pain threshold: mean difference 2.6 (95% CI 2.4 to 2.8); pain tolerance: mean difference 4.9 (95% CI 5.0 to 4.8)]. Cryotherapy in combination with burst TENS provided greater analgesia compared with the other groups ($P < 0.001$).
Conclusion These results support the use of cryotherapy in combination with burst TENS to reduce induced pain, and suggest a potentiating effect when these techniques are combined. No such association was found between cryotherapy and conventional TENS.

Keywords: Ice; Analgesia; Electrotherapy

Introduction

Pain is a common symptom in a number of pathological conditions, and physical therapists have several resources at their disposal, including transcutaneous electrical nerve stimulation (TENS) and cryotherapy. One technique gaining popularity in clinical practice is the simultaneous application of ice and TENS [1,2]. Despite the large number of studies supporting the effectiveness of TENS for analgesia [3–8], there is no consensus about adequate stimulation parameters [4,5,9,10] or the action mechanisms involved [4,11]. Furthermore, studies often have methodological differences, which may account for the wide range of conclusions [12,13]. TENS, which consists of applying an electric current to relieve pain through electrodes placed on the surface of the skin [3,4,13–15], is commonly used as

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non-invasive non-pharmacological coadjuvant treatment and is largely free of side effects [4,14]. Four levels of stimulus intensity can be adjusted in TENS units: subsensory, sensory, motor and noxious. The sensory level is most widely used in clinical practice and research studies [16]. The literature shows that TENS results depend on the application site [9] and stimulus characteristics, such as amplitude, frequency and pulse duration [4,8,10].

Conventional TENS can be applied to frequency parameters with a range between 50 and 100 Hz, short pulse duration (from 50 to 100 μseconds) [16] and amplitude regulated according to the patient's report: strong paresthesia, more comfortable and no muscle contraction or pain [3,9,15,16] is considered to be a high-frequency, low-intensity mode [15]. Studies have indicated that the action mechanism which underlies the effectiveness of this type of stimulus for the production of analgesia is based on Melzack and Wall's gate control theory of pain [17]. This theory proposes that pain perception is controlled by the balance between large-diameter non-nociceptive fibres (Aβ fibres) and their small-diameter nociceptive counterparts (Aδ and C fibres) that reach the gelatinous substance, resulting in T-cell excitation or inhibition. Sensory-level TENS, therefore, acts by selective activation of sensory fibres, increasing their input and inhibiting T cells, thereby decreasing pain via segmental inhibition. As such, analgesia will cease as soon as the stimulus is terminated [3].

Concerning burst TENS, Robinson and Snyder-Mackler [16] reported that 'bursts of brief pulses are applied at levels that cause muscle contraction as a means of controlling pain; this stimulation mode is known as burst-modulated TENS'. This mode, characterised as low-frequency, high-intensity stimulation [4], is applied under high-frequency carrier waves (80 to 100 Hz), modulated in low-frequency pulse trains (2 to 5 Hz) [18], with a long pulse duration (>150 μseconds) and sufficient amplitude to produce strong and visible, albeit painless [16], muscle contractions. Painless induced contractions may simply relieve pain in the same way as sensory-level stimulation (via pain gates). Moreover, it has been demonstrated that low-frequency TENS activates opioid receptors in the spinal cord and brain stem, given that motor-level analgesia is generally non-immediate but long-lasting [4,16].

Although there is no consensus in the literature regarding the terminology used in the different modes of TENS (conventional/high-frequency and burst/low-frequency), the present study adopted the classification proposed by Robinson and Snyder-Mackler [16].

The term 'cryotherapy' refers to the removal of body heat, with a reduction in skin temperature in order to reach a therapeutic objective [19]. Saeki [20] reported that ice can be used in various ways to relieve pain, including decreasing nerve conduction velocity (NCV), pain gate activation, activation of descending tracts from the central nervous system (release of endogenous opioids) and counter-irritation mechanisms (via diffuse noxious inhibitory control). In the latter case, somatic or noxious stimuli can be used to relieve pain by changing beta-endorphin or encephalin levels in both plasma and cerebrospinal fluid [16].

A recent technique that has been used increasingly in physical therapy is cryo-TENS, which consists of the simultaneous application of ice and TENS. In addition to enhancing analgesia, it is suggested that the simultaneous application of an electric current and a cold stimulus could reduce discomfort by altering pain perception through the nociceptive pathways [2]. According to Santuzzi *et al.* [1], treatment with ice and conventional TENS attenuated electrical activity in the femoral nerve of rats compared with TENS alone, likely reversing the analgesic effects produced by separate techniques. Although there are few studies on this technique and no scientific proof of its effectiveness, clinical use is growing and patients report greater pain relief and improved comfort with this therapy [7]. Given patients' preference for using the two techniques concomitantly rather than separately, and the scarcity of studies that confirm its effectiveness, the effects of applying cryotherapy and TENS simultaneously is called into question. As such, this study aimed to assess the immediate effects of TENS, with or without cryotherapy, on pressure pain threshold and tolerance using pressure algometry.

Materials and methods

Characterisation of the study

This randomised controlled experimental trial assessed the effect of conventional and burst TENS in combination with cryotherapy on pressure pain threshold and tolerance. The study was conducted at the Laboratory of Neuromuscular Performance Analysis, located in the Physical Therapy Department of the Federal University of Rio Grande do Norte, Natal, Brazil.

Subjects

One hundred and twelve healthy young female volunteers {mean age 21.9 [standard deviation (SD) 1.95] years, mean body mass index (BMI) 20.7 (SD 2.05) kg/m^2} were selected for the study. Based on initial values obtained in pilot studies, at least 16 subjects were required per group for a power of 80% ($\alpha = 0.05$).

The inclusion criteria were: age between 18 and 25 years, no history of upper limb injury in the last 6 months, BMI <28 kg/m^2, and not using analgesic medication. Furthermore, for inclusion, subjects could not exhibit skin or vascular alterations or sensitivity. Exclusion criteria were: allergy to ice (positive ice cube test), or failure to tolerate any of the interventions. None of the volunteers were excluded from the study.

Subjects were recruited by non-probability, convenience sampling and distributed at random using www.randomization.com. All of the subjects were volunteers and gave their informed consent, in accordance with