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Whole- and partial-body cryostimulation/cryotherapy: Current technologies and practical applications

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ABSTRACT

Cold therapy is commonly used as a method to relieve pain and inflammation. This review focuses primarily on two methods of cold therapy that have received recent attention: whole-body cryotherapy and partial-body cryotherapy. These methods are used to induce physiological and psychological benefits in humans in the context of medicine, health and sports. The subjects experiencing cryotherapy are dressed in minimal clothing and are exposed to very cold air (at −110 °C or less) for 1–4 min. Despite the increasing scientific interest in these methods, there is a lack of information about the technologies used. Moreover, there is no existing reference concerning exposure protocols and the relationship between temperature, duration, number of repetitions and the treatments' desired effects. The aim of this review is to compare whole- and partial-body cryotherapy effects (especially on skin temperature) and to classify the protocols for exposure according to the desired effects. This review emphasises 1) the lack of information concerning the actual temperatures inside the cabin or chamber during exposure and 2) the heterogeneity among the exposure protocols that have been reported in the scientific literature.

This review will be valuable and relevant to health professionals endeavouring to optimize the cold treatments offered to patients and producers of cryotherapy apparatus striving to create more efficient devices that meet market requirements.

Contents

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1. Introduction

The use of cold in medicine has been known since antiquity. In various ancient cultures, it was one of several traditional methods for relieving physical suffering. In ancient Greece, Persia and the Roman Empire, cold remedies such as snow, ice-water mixtures and cold water were applied to treat a wide range of diseases. In contemporary times, winter swimming—regularly taking a bath in ice-cold water during the winter season for health reasons—has become a popular practice in Nordic countries (Dugue and Leppanen, 2000). Winter swimmers believe that they become sick less often and that cold stimulation improves their ability to address with daily stress (Huttunen et al., 2004; Lubkowska et al., 2013). Today, cold application remedies are being developed in the medicine, health and sport domains. This review primarily focuses on two recent methods of cold therapy: whole-body cryotherapy (WBC) and partial-body cryotherapy (PBC). WBC and PBC are two methods that expose a patient to extreme cold for a short time, and both require a specialised cold chamber (cryochamber) or cabin (cryo-cabin). These methods are used to induce physiological and psychological benefits.

Little known a few years ago, these therapies have recently been the subject of tremendous interest. According to PubMed, there were approximatively 30 scientific studies concerning this topic before 2010 and there have been over 100 since then. The two most investigated domains are improvements in mental and physical health and improvements in recovery after physical exercise (Bleakley et al., 2014; Guillot et al., 2014). The populations studied include patients suffering from traumatologic, inflammatory or mental diseases, healthy individuals (no sport and no disease), and athletes (all levels) as well as active participants (moderate level of sport activity). In addition to the term “cryotherapy”, the term “cryostimulation” has emerged. Although the cold stimulation is the same, cryostimulation is targeted to subjects with no pathologies (e.g., healthy athletes), whereas cryotherapy involves patients.

Since the invention of PBC and WBC, several technologies for each have emerged and, there are approximately fifteen producers worldwide (Table 1). The differences between the two methods involve the exclusion of the head in PBC treatment, different ways to create cold, and different device sizes and mobility possibilities, which can attract different populations of users (Hausswirth et al., 2013). PBC uses a moderate-sized mobile device, whereas WBC employs a larger fixed device. Thus, PBC is used more in the field with sport teams, and WBC is used more often in rehabilitation or athletic sport centres.

The differences in the temperature of exposure inside the two devices are not clear. Currently, there is no standardised method of assessing these temperatures. The temperatures reported are those provided by the device producers. With the exception of three cryo-cabin models (Criomed, Kherson, Ukraine; Juka, Niepolomice, Poland; and Cryo Manufacturing, Perigny, France), in which temperatures are measured at the outlet of the nitrogen nozzle (Bouzigon et al., 2014; Savic et al., 2013), the site of assessment of cabins and chambers remains unknown. This lack of data is a problem for the validity of assessments in scientific research. It is not possible to know precisely what exposure temperatures were used in different studies. Furthermore, several articles (Tables 2–4) do not disclose the brand, model, producer and origin of the devices used in their materials and methods sections.

An interesting way to measure the efficiency of the different cryotherapy/cryostimulation technologies is to assess the variations in the cutaneous temperature induced by exposure. The strong variations in skin temperature induced by exposure to extreme cold lead to the stimulation of cutaneous thermoreceptors and therefore to the stimulation of the thermoregulation centre in the hypothalamus. The sympathetic adrenergic fibres are excited, which causes local arterioles and venules to constrict and reduces nervous conduction velocity (Herrera et al., 2010). Core and muscular temperature could also be affected. However, short cold exposure does not induce a large decrease in these temperatures immediately after treatment (Costello et al., 2012b; Westerlund et al., 2003).

WBC and PBC were first used to relieve rheumatic and inflammatory diseases such as rheumatoid arthritis (Hirvonen et al., 2006), fibromyalgia (Bettoni et al., 2013) or ankylosing spondylitis (Stanek et al., 2015). Currently, these methods are also being used in psychiatry to improve mental well-being, but there are only few studies on this topic. WBC and PBC treatments are used to relieve depression and anxiety syndromes (Rymaszewska and Ramsey, 2008). Previously, investigations in winter swimmers were performed to assess the effect of cold on well-being (Huttunen et al., 2004, 2001). In these studies, the adaption to cold was associated with a decrease in tension and fatigue and with an improvement in mood and memory. Winter swimmers reported feeling more vigorous, energetic, and active after a winter swimming period of four months (Huttunen et al., 2004). WBC and PBC were later used in the sports domain because cold exposure studies demonstrated their potential to enhance physical exercise recovery.

Though not completely clear, the mechanism leading to pain release and inflammatory symptom alleviation as well as recovery improvement after physical exercise appears to be related to cold-induced analgesia and cold-induced lower levels of oxidative stress and inflammation (Hausswirth et al., 2011; Leppaluoto et al., 2008; Pournot et al., 2011; Lubkowska et al., 2010; Lubkowska et al., 2012; Lubkowska et al., 2011). Cold stimulus reduces nerve conduction and acetylcholine formation (Bugaj, 1975). However, the stimulation of the sympathetic system, the release of noradrenalin and the vasoconstriction during and after the cold exposure may also have a significant impact on pain and joint and/or muscle soreness (Leppaluoto et al., 2008). Noradrenalin is released both from peripheral nerve endings and brainstem nuclei (Pertovaara et al., 1991). Moreover, noradrenalin spinal administration in animals and epidural injections of an adrenoceptor agonist in humans have been reported to alleviate pain (Pertovaara and Kalmari, 2003; Gordh, 1988). Circulating noradrenalin reaches the