A new multimodal orthosis for non-invasive musculoskeletal pain management

Abstract

Chronic musculoskeletal pain is highly prevalent and costly disorder, which dramatically degrades the patient life quality, so it becomes one of the global healthcare concern. Several methods have been proposed for management of this problem including, but not limited to different type of braces and physical agent modalities. In this paper, we present a new generation orthosis, hope to be effective in management of chronic musculoskeletal pain. This orthosis, as a complementary treatment, will help patients to self-control their pain during the home-based rehabilitation process.

Keywords: orthosis, physical therapy, musculoskeletal pain, home-based rehabilitation

Introduction

Chronic musculoskeletal pain (CMPs) has been reported as a common occurrence and poses therapeutic and prognostic challenges for orthopedic surgeons (1). A wide variety of population from students to debilitating disease are susceptible to this problem (2, 3). The related studies show that patients with chronic musculoskeletal have a degraded level of life quality (4), as well as higher level of depression & anxiety (5). The Knee, shoulder and spinal column have been identified as the most frequent sites of musculoskeletal pain (6-8).

Numerous clinical practice guidelines exist that are applicable for the management of chronic musculoskeletal pain in primary healthcare. According to these guidelines, CMPs management has different content sections. Most important sections of this process are pharmacological therapy (opioid & non opioid), physical therapy & psychologically based therapy(1).

Physical therapy & orthoses have been suggested as independent methods for different musculoskeletal pain management (9). Physiotherapy usually involves a multimodal approach to that may include but not limited to physical agent modalities, exercise, manual therapy, massage and other techniques to reduce pain (10). Heat, cold, and vibration are common used physical agent modalities that are pleasant and well tolerated by the patients (11). Heat application in physical medicine includes musculoskeletal conditions (tendonitis, tenosynovitis, capsulitis, bursitis, etc.), pain (12) (neck, low back, myofascial, neuromas, postherpetic, neuralgia, etc.), arthritis, contracture, muscle relaxation and chronic inflammation. Some of clinical applications of cold are musculoskeletal conditions (sprains, strains, tendonitis, etc.), after certain orthopedic surgeries, component of spasticity management, emergency treatment of minor burns. Vibration is also used for pain management, relaxation, and recently for osteoporosis treatment.

On the other hand, orthoses (braces) are worn over a part of the body in order to help pain reduction. They can be used with or without other treatments such as non-steroidal anti-inflammatory medications or exercise. According to the best of our knowledge, there is no orthosis that can be used for simultaneous thermo/vibration therapy.

Technical note

The structure of proposed system is shown in the figure1. The system controller and electrical parts can be kept the same, while the orthosis shape is changed in order to fit to different body joints. The system consists of:

1- Knee orthosis include temperature sensor, heater/cooler/vibrator module.
2- Back orthosis include temperature sensor, heater/cooler/vibrator module.
3- Shoulder orthosis include temperature sensor, heater/cooler/vibrator module.
4- Wrist orthosis include temperature sensor, heater/cooler/vibrator module.
5- Temperature sensor and heater module which is embedded inside 1, 2, 3, and 4.
6- Control box.
7- Display unit.
8- Keyboard unit.

9- Main power supply and battery charger unit.
10- Battery unit.
11- The related electronic board which is placed inside 6.

The amount of required temperature/vibration can be programmed by user through the keyboard unit. The environment temperature is monitored by the control box from the sensor with 0.1°C resolution. So based on the setting, the heater/cooler and vibrator will be powered on or off. The actual temperature of the orthosis is shown to patient in real-time mode as well.

Compared to usual braces, a number of advantages can be pointed out for the proposed device:

1- The portability of device lets the patient to gain the beneficial effects of heat, cold, and vibration in any place during normal daily life, not only in a physiotherapy clinic.
2- Based on its user-friendly design, it can be worn and adjusted by the patient. We believe it can be as a part of home-based rehabilitation for musculoskeletal pain in near future.
3- There are several precautions for the use of heat in the clinics. Superficial heat has sedative effects and the client is typically not directly supervised when this modality is used, so hot packs are among the more common causes of burns in physical therapy. In the proposed device, the temperature is controlled by a sensor in ±0.1°C, moreover, the pick temperature is closed at 45°C, so the risk of patient burning is minimal.
4- Primary sample of the proposed orthosis maintains its battery charge around 1 hour (twice more than it is needed for a usual heat therapy session). Obviously, by using more powerful batteries, it would be possible to prolong its working time.
5- The device seems to be very cost effective. A course of physiotherapy (10 sessions) at a private clinic costs more than 100$, while the price of an orthosis in commercial scale production would be less expensive. Moreover, the orthosis can be used several times.
6- This orthosis can play an important role in research, where the effect of different hot, cold, and vibration modalities are in the center of interest.

Obviously, the optimal temperature range and/or vibration frequency is variable from patient to patient according to the background diseases and his tolerance. The orthosis is designed to set the temperature of skin from 33-to-42°C /8-to-17°C in warm/cold mode respectively. According to the best of our knowledge, it is enough to cover most of clinical situations (13, 14). Frequencies of vibration can be adjusted in the range of 0.1-to-10Hz.

It should be mentioned that the weight of first developed version, which has been made for lumbosacral support, is only about 220 grams. The first prototype has been developed in "Biomedical Instrumentation" lab, Faculty of Engineering, Ferdowsi University of Mashhad.

Discussion

The orthosis will be tested as a pilot study in limited number of volunteers to determine any possible adverse effect in near future. The orthosis also needs to be tested on more clients after the study will be approved by local ethical committee and results need to be taken into account after using larger sample sizes. In this case, we will be able to adjust the orthosis

parameters for maximum accuracy/efficiency. The results should also be compared to the existing orthoses.

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