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Assistive device for patients having spondylitis and spondylosis

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1 Background

Spondylitis is a very common back and neck ailment that is reported to account for one-third of social problems causing difficulty at work. It is caused due to the inflammation in vertebral joints. Its condition goes undetected until the symptoms, such as that of severe pain, develops. It causes stinging pain which is focused around cervical region of vertebra, the shoulders and the lumbar region of the spine. Accordingly, it is classified into three types: cervical, thoracic and lumbosacral spondylosis. This is different from spondylitis which causes pain due to inflammation.

Many existing devices use electric current to bring relief from pain. Transcutaneous electrical nerve stimulation (TENS) is one of the most commonly used devices in this aspect. However, though this has been able to bring effective results to its patients, there is a whole lot of controversy in conditions it should be used to treat.

Studies have shown these devices to bring relief by suppressing the signals from the brain. They are not advised for patients with pacemakers or any kind of electronically powered implantable devices. They are less effective where the skin is numb or in places where there is decreased sensation. It depends entirely on the working of the nerve beneath the surface and may cause irritation on the skin if the current is too high. Moreover, these devices need to be avoided in area where infection is present. High precaution needs to be taken when working with epilepsy patients and pregnant women; the electrical stimulation can interfere with the fetus development.

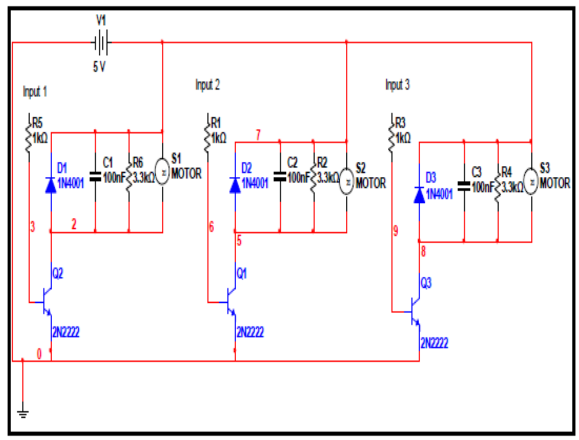
With such a wide range of drawbacks, there is a need for a mechanical solution which can redress these problems and provide an effective and ergonomic solution. Along with overcoming the present barriers, research has been done to demonstrate the positive effects of vibration in increase of bone density, increase of muscle mass, increase of blood circulation, reduced back pain, reduced joint pain and boost in metabolism. The given paper discusses a device wherein vibrational motors have been incorporated, under the control of a microcontroller, to generate the requisite g-force needed for the purpose of pain alleviation and increase of bone density.

2 Methods

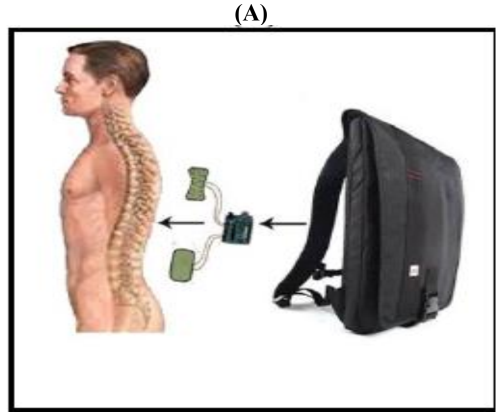
2.1 Experimental set-up. The system consists of motors mounted on a patch placed in close vicinity to body. The motors need to be placed in a way such that the axis of rotation of the axle is parallel to the direction in which the device is placed. This positioning makes sure that the motor's rotation is not blocked by the body.

A toggle switch is used to turn the device on and off while button switches controls functioning of motors in different regions. The motor is able to rotate at 12000 rpm (200 Hz) and generates vibration ranging from 0.2 to 0.5 g.

As shown in figure 1(b), an important application of this device is with a bag. This device would be attached to it in such a way that the motors are placed right on the pressure points of the vertebra. The device can be switched on during times of need and any of the operating modes of the device can be used to relieve body from pain.



(A)



(B)

Fig. 1 A) Circuit for controlling vibrational motors B) System Setup

2.2 Hardware set-up. The proposed system makes use of vibrational motors to deliver the treatment to the body. The motor is capable of producing voltage spikes as it rotates. To protect the system from these, there is a capacitor (100nF) and a diode present. The capacitor absorbs these voltage spikes which are produced when the contact surface of the electric current to the motor winding, open and close. The diode is present in reverse bias and is needed only when the power source is not DC voltage. It works to protect the system from voltage surges.

The microcontroller supported by a transistor drives the motor. The amount of current needed by the motor is 75mA. However, the motor too has its safety limits on the amount of current that can pass through it and thus, a 3.3KΩ resistor is employed. As depicted in figure 1(a), the circuit consists of three motors which can be mounted on the surface of the vertebra.

2.3 Working Principle. Vibration technique has been used effectively by many athletes and astronauts to increase bone density. Since spondylosis causes degeneration of the spine and intervertebral disks, this technique will help the patients substantially. The induced vibration to the muscles causes them to relax and contract. This activity promotes an environment where osteoblasts cells are produced and increases the bone density. This action also alleviates pain due to inflammation, as seen in spondylitis.

The system works by the vibrational effect brought about by the motor. This effect is caused due to the presence of a half cut mass on the motor surface. This mass is attached to the axle and causes imbalance in the weight of the motor. Thus when the axle rotates it causes the weight to shift from side to side. This effect, in high speed, produces the vibration.

Though many more motors could be involved, the prototype, as shown in figure 2(a), works with 3 motors, one for the cervical region, one for thoracic region and the third for the lumbar region of the spine which are made to function in three different modes with the help of Arduino Mega board, which is powered by a 5V battery:
i) Continuous Mode- the motor runs continuously providing uninterrupted vibration at point of contact.
ii) Pulse Width Modulation (PWM) – A PWM wave of 50% is generated with the Arduino. This mode gives a delay of 1sec. for every 1sec. of work and is recommended when device is being used for longer durations.
iii) Fade Mode- In this mode, the speed of the motors goes progressively from high to low. This pattern is like a sine wave of 5sec. width, where the peak denotes a point where the motor is running the fastest (12000 rpm).

3 Results

The design and working principle of the device is successfully described. Fig. 2(a) shows the device set-up. It utilizes localized vibration to apply pressure on specific regions of the body. Though the tolerable range for whole body vibrations has been defined to be 20 Hz to 50 Hz, with localized vibration, this can extend from 300 Hz to 500 Hz. The vibrational motors utilized was observed to rotate at speeds up to 12000 rpm (200 Hz) and cause vibrational levels ranging from 0.1 g to 0.6 g. The tolerable levels of g-force are given in Fig. 2 (b).

4 Interpretation

The device offers a cost-effective ($10) mechanical method to deal with spondylitis and spondylosis. The motor's standard operating temperature ranges from -20˚C to 60˚C and follows the vibration standards. It can be used as an alternative for the presently used bulky and more expensive solutions. Moreover, it delivers a much safer treatment and can be used in most cases including when the patient is wearing an implant. However, like other developed solutions, it cannot be used at an infected site.

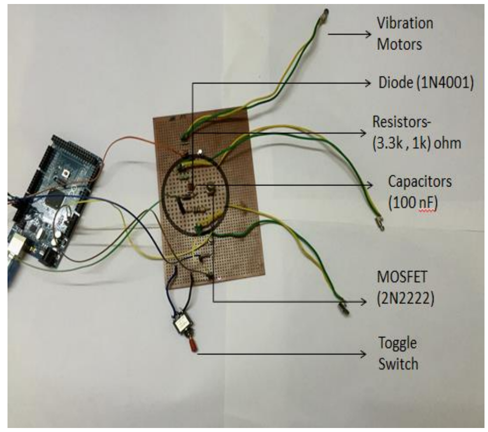


Fig. 2(a) Device Setup

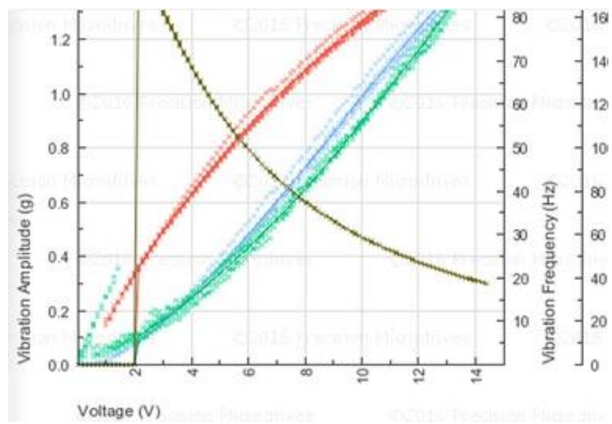


Fig. 2(b) g-force specifics of the device
Courtesy: www.precisionmicrodrives.com

References

[1] Antonella Savoia., Simone Landi., Fulvio., Vannini and Alfonso Balder., 2013, "Low-Level Laser Therapy and Vibration Therapy for the Treatment of Localized Adiposity and Fibrous Cellulite" Dermatol Ther, 23;3(1), pp. 41-52.
[2] T. Y. Lee., and D. H. K. Chow., 2013, "Effects of Whole Body Vibration on Spinal Proprioception in Normal Individuals" Conf Proc IEEE Eng Med Biol Soc., 2013 pp. 4989-92.
[3] Adeyemi Ademola James., Jafri Mohd. Rohani., Mat Rebi Abdul Rani., 2012, "Development of a Holistic Backpack-Back Pain model for school children" Network of Ergonomics Societies Conference (SEANES).
[4] Weiqing Ge and Joel G. Pickar., 2005, "Change of Paraspinal Muscle Spindle Resting Discharge Evoked by Mechanical Vibration" Conf Proc IEEE Eng Med Biol Soc. 2005;5:5002-5.