Economically accessible vibration vest for respiratory physiotherapy

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Abstract. *Respiratory physiotherapy of patients with spinal cord injury is based on a pressure applied to the patient's chest followed by a vibration performed by the physiotherapy professional himself. This paper presents a device for the optimization of respiratory physiotherapy by obtaining higher pressure and frequency of movement execution through digital electronics adapted to an adjustable vest.*

Resumo. *A fisioterapia respiratória de pacientes com lesão medular é feita a partir de uma pressão aplicada no peito do paciente seguida de uma vibração feita pelo próprio profissional de Fisioterapia. Este trabalho apresenta um dispositivo para otimização da fisioterapia respiratória a partir da obtenção de maior pressão e frequência de execução do movimento através de eletrônica digital adaptada a um colete ajustável.*

1. General Information

When the spinal cord is completely or incompletely injured, muscles below the injury level may become paralyzed, including the muscles responsible for breathing. This interferes with the integrity of the remaining muscles and reduces the ability to move the trunk efficiently. Patients with cervical lesions have greater impairment of lung function than those with low thoracic and lumbar injuries [Colman 2010].

Pulmonary complications are responsible for more than 50% of deaths in spinal cord injuries. Mainly patients with cervical spinal cord injury. For with the paralysis of intercostal muscles and other expiratory muscles the patient has ineffective cough and difficulty expectorating the secretion. Thus being conducive to the onset of atelectasis and pneumonia, precipitating or aggravating respiratory failure [Colman 2010].

One of the basic objectives of Respiratory Physiotherapy is to facilitate mucociliary clearance through bronchial hygiene maneuvers, aiming at maintaining airway permeability, avoiding secretion accumulation and facilitating gas exchange [Manzano 2014].

The forms of treatment for such pulmonary complications are Bronchial Hygienic Maneuvers (BHG), which are techniques, which aim to assist in the mobilization and removal of retained secretions, prevent or reduce secretion obstructions and their consequences, such as hyperinflation, atelectasis, change in ventilation / perfusion ratio and increased respiratory work [Targino, 2017]

Vibrocompression constitutes vibrations associated with chest compressions on the chest or hemithorax to be treated. Such vibrations are applied intermittently, slowly and steadily during the expiratory phase, from a moderate force that facilitates mobilization of airway secretion and pulmonary reexpansion, thus improving pulmonary ventilation [Liebano 2009].

Can be performed manually or with the use of electrical appliances, when used by these electrical devices, usually are less efficient. This occurs because such electrical equipments do not have specific or individual anatomical contours for each chest, thus their vibratory effects end up reaching unnecessary body segments, being uncomfortable for the patient [Mendes 2011].

On the other hand, the literature lacks information on vibrocompression in patients with spinal cord injury, and the vast majority of descriptions of this maneuver do not mention the frequency with which it should be performed. Some authors present divergent values, ranging from 3 to 75 Hz, being from 3 to 17 Hz effective in pediatrics. Given the above scenario, further studies are needed [Corrêa 2012].

2.Justification

The current manner in which respiratory physiotherapy is performed in people with spinal cord injury is restricted by human limitations. The human hand cannot reach the required frequency of beats in the patient's rib cage so that the movement is fully functional and can assist the patient in mucociliary clearance [Mendes 2011].

There are devices that automate or proceed, one of them is the MeCan model MCR-V11, the product in question, and it is not possible to find results of efficiency and effectiveness, it is only available for values above $ 2000.00 (two thousand dollars), but it is not accessible due to its high cost and difficulty of importation.

The present work proposes to use a microcontroller, vibration motors and an air chamber, aiming the automation of the procedure. From automation, the aim is to obtain a constant frequency and pressure in the patient's rib cage and, therefore, a greater accuracy and improvement of the results achieved by respiratory physiotherapy.

3. Goals

1.1 General Goal

The overall objective of the proposal is to develop a vest for automation and control of chest pressure and vibration in respiratory physiotherapy patients to stimulate mucus expectoration from the lungs.

2.2 Specific Goal

As specific objectives we intend to analyze the results obtained from the use of the proposed vest and compare these results with those obtained before the vest. Also part of the present proposal is the narrowing of the adoption of technology, in this work implemented through automation, in health care, aiming to assist physical therapists.

3. Methodology

From studies at the Physiotherapy clinic of a University Center in Northern Brazil – *Centro Universitário do Estado do Pará* (CESUPA), it can be seen that the method used to perform respiratory physiotherapy in persons with spinal cord injury do not have the necessary efficiency for the patient to secrete the phlegm in his lungs.

Currently applied physical therapy is manual, which provides neither the patient nor the physical therapist, an adequate precision to perform the procedure effectively. The procedure is done with the physiotherapist exerting a pressure together with the vibration of the hands on the patient's ribcage at a frequency that reaches approximately 9 to 14 Hz. Such frequency, according to studies, is only suitable for the treatment of children, being necessary. a frequency of 70Hz for an average adult.

The Respiratory Assist Vest will be developed with 2 air chambers, taken from an unused sphygmomanometer (Figure 3), or inflated with an air compressor, so that together it exerts pressure exerted on the patient's chest, together with Vibration motors (Figure2) spread over the vest, which are responsible for performing a vibration at the correct frequency (70 Hz) in the patient's rib cage, thus assisting more efficiently in the patient's physical therapy. For greater control of all electronic equipment, an Arduino UNO (Figure 1) will be used.

Figure 1. Microcontroller used to control the system

Figure 2. Vibration motor model used to vibrate at the correct frequency (70Hz)

Figure 3. Sphygmomanometer used to build the pneumatic chamber

3. Results

As a result of the development of the vest, we have the pneumatic chamber assembly, together with the air compressors and vibration motors, which will be arranged according to (Figure 4), inside a vest, which is being designed to be adjustable. In order to be adjustable for as many patients as possible, this will be done via the velcro.

The prototype is under development, with its pneumatic camera, which will be responsible for making the pressure on the patient's chest, is nearing completion, with only one new air chamber similar to the larger one, shown in Figure 5, also forming. the pneumatic chamber are the air compressors, also shown in figure 5, along by the Arduino, which is being used to control both the motor start time and the vibration motor, figure 2.

The prototype of the device in conclusion phase and will be used in the physiotherapy sessions of the physiotherapy clinic of CESUPA, with a control group, which will be evaluated simultaneously the conventional techniques of respiratory physiotherapy, for evaluation of therapists after 6 months of use.

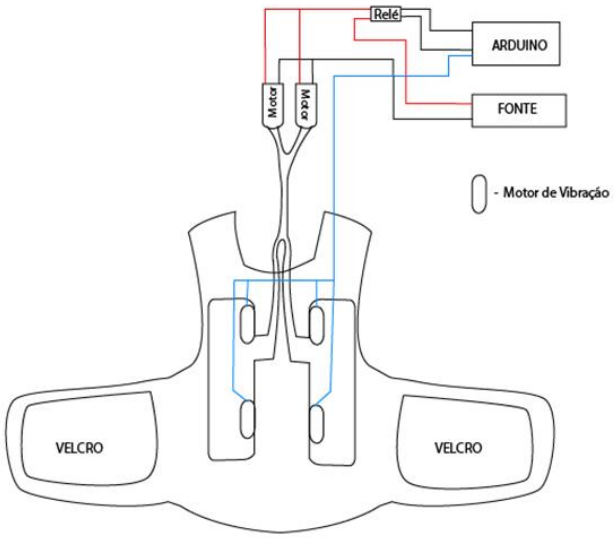

Figure 4 - Schematic of how everything will be arranged on the vest

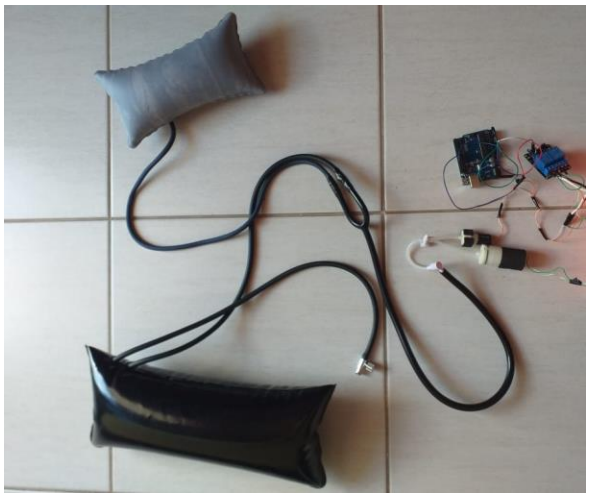

Figure 5. Current stage of development

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