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Incentive Spirometer and Respiratory Muscle Training Devices: What Do Physiotherapists Need to Know?

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Abstract

Physiotherapy plays a crucial role in pre-habilitation, post-operative care, and rehabilitation to reduce postoperative pulmonary complications. The use of various devices like incentive spirometers, and respiratory muscle training devices is an integral part of chest physiotherapy. Currently, there are many devices available in the market, which have been used in physiotherapy. Despite their regular use in the clinical setup, many clinical practitioners do not have thorough knowledge about their functioning and effect. This article intends to make physiotherapists aware of the types, components, teaching techniques, and uses of such devices, to have optimal and specific benefits. The knowledge of these devices may help professionals to select the best device to be used. To select the most appropriate one, it is also necessary to consider the specific health condition, the nature of the impairments, the purpose of the training, and whether its use is within a research or clinical context.

Keywords: Incentive spirometer • Volume targeted spirometer • Flow targeted spirometer • Respiratory muscle training devices

Introduction

As per the recent data, the incidence of Postoperative Pulmonary Complications (PPCs) in major surgery ranges from <1% to 23%. Many studies have shown that pulmonary complications are more common than cardiac complications during the post-operative period. According to the European joint task force PPC includes respiratory infection, respiratory failure, pleural effusion, atelectasis, pneumothorax, bronchospasm, aspiration pneumonitis, pneumonia, Acute Respiratory Distress Syndrome (ARDS), pulmonary embolus, etc. Post-operative respiratory failure is the most common among them [1]. Physiotherapy plays a crucial role in preventing and treating PPCs through pre-habilitation, post-operative therapy, and rehabilitation [2,3]. Chest physiotherapy, Deep Breathing Exercises (DBE), Postural Drainage (PD), Active Cycle Breathing Technique (ACBT), Incentive Spirometry (IS), and Respiratory Muscle Training (RMT) are components of physiotherapy [3,4]. RMT has growing evidence about its efficacy and effectiveness. Although incentive spirometry is widely used clinically as a part of a routine prophylactic and therapeutic regimen in pre-operative and post-operative respiratory therapy, its clinical efficacy remains controversial due to inadequate evidence. Despite their regular use in the clinical setup, many clinical practitioners do not have thorough knowledge about the functioning and effect of these devices. To the best of our knowledge, such an informative article is not available; this made us focus on this area. This article intends to make physiotherapists aware of the types, components, teaching techniques, and uses of the various types of devices.

Incentive spirometer

An incentive spirometer is considered one of the commonly used adjuncts indicated in pulmonary rehabilitation. It is a mechanical device, which works on the principle of Sustained Maximal Inspiration (SMI), by encouraging the patient to take long, slow, deep breaths using visual feedback and indicated to improve the respiratory capacity of the user [5].

The objective of the incentive spirometer usage is to, enhance inspiratory muscle performance, simulate the normal pattern of pulmonary hyperinflation, and increase trans-pulmonary pressure and inspiratory volumes. Long, slow, deep breaths, decrease pleural pressure and promote lung expansion and better gas exchange [6]. It also improves ventilation/perfusion mismatch and alveolar PaO_2 gradient, which is suggestive of improved alveolar ventilation and subsequent reduction in the intrapulmonary shunt. It helps to maintain PaO_2 levels near normal when sustained maximal inspirations are repeated every hour. When the procedure is repeated daily, atelectasis is prevented or reversed [7].

Indications

- Presence of pulmonary atelectasis or conditions predisposing to the development of pulmonary atelectasis like upper-abdominal, thoracic, cardiac, or lower-abdominal surgery,

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prolonged bed rest, surgery in patients with COPD.

- Obstructive conditions like COPD, and bronchial asthma to strengthen respiratory muscles.
- Extra-pulmonary restrictive impairments related to a dysfunction of the diaphragm or other respiratory muscles like in patients with neuromuscular disease or spinal cord injury.
- Pulmonary restrictive impairments like ILD to improve lung volumes or strengthen respiratory muscles.
- To strengthen the inspiratory/ expiratory muscles in patients on mandatory ventilation to assist in successful weaning from the ventilator.

Contraindications

- Patients who can't be instructed or supervised to assure the appropriate use of the device.
- Non-cooperative or non-comprehensive patients.
- Very young patients (four years or younger) and others with developmental delays.
- Patients who are confused or delirious.
- Patients who are heavily sedated or comatose.
- Patients unable to take a deep breathe effectively due to pain, diaphragmatic dysfunction, or opiate analgesia.
- Patients with moderate to severe COPD and acute asthma have an increased respiratory rate and hyperinflation.

Hazards and complications

- Barotrauma (emphysematous lungs).
- Hyperventilation.
- Discomfort secondary to inadequate pain control.
- Hypoxia secondary to interruption of prescribed oxygen therapy if face ma ask or shield is being used.
- Exacerbation of bronchospasm.
- Fatigue.

Types

Various types of incentive spirometers are commercially available.

Depending on their working mechanism, they are either volume targeted or flow targeted [8].

Literature Review

Volume targeted spirometer: This type of device has a chamber, which has volume measurements displayed on it. A piston within the chamber rises when the patient inhales air from the spirometer. Due to less work of breathing, this type of device is preferred [9]. This type of incentive spirometer provides appropriate feedback about the volume inhaled during slow sustained inspiration. Pediatric (Figure 1) and adult (Figure 2) variants of this type are available.

Figure 1. Pediatric spirometer.

Figure 2. Adult spirometer.

Parts of the spirometer: This incentive spirometer is made up of a mouthpiece, a flexible corrugated breathing tube, an air chamber, and an indicator (either piston or ball). The breathing tube is connected to the air chamber and encompasses a mouthpiece at the opposite end. The indicator is found inside the air chamber. A few models also have a slider, which can be moved manually to set the target [10].

Target: In the case of the volume targeted spirometer, the patient aims to attain a preset target volume. The patient is instructed to reach a volume goal that is dependent on their height and age. The patient receives visual feedback from the piston rising to the predetermined level. The patient is instructed to hold his breath for at least 2-3 seconds at full inspiration [11]. These devices encourage slow and controlled inhalation while maintaining a disc at the target volume *i.e.* end-inspiratory hold and flow marker at the optimal level. Patient is instructed to inhale within an 'ideal' flow rate by keeping the flow indicator within the prescribed range and inhaling as deeply as possible at the same time.

Mechanism: Volume targeted devices not only impose less work of breathing but also improve diaphragmatic activity. In a recent study, it was observed that volume incentive spirometry has resulted in early recovery of both pulmonary function and diaphragm movement in patients who had undergone laparoscopic abdominal surgery [12].

Flow-targeted incentive spirometer: These spirometers have been popularly used in postoperative conditions as adequate inspiratory flows are required for airway clearance techniques like huffing and coughing. Thus they assist in airway clearance by improving inspiratory flows. These flow-targeted devices set the target of desired flow. Variants of the flow-targeted incentive spirometer like a triple ball (Triflow), single ball, and pediatric are available.

Triflow

Triflow (Figure 3) encompasses three interconnected columns within which lightweight plastic floats are seated. Each column has printed on the outside of the column the least amount of flow needed to raise the ball. With an airflow rate of 600 to 1200 ml/second, deep breath lifts the balls. When all three balls reach the top of the spirometer, the patient has achieved a flow speed of 1200 ml/second. The number of balls and also the level to which they rise depends on the magnitude of the flow achieved. At lower flows, depending on the magnitude of the flow the first ball rises. As the inspiratory flow increases, the second ball rises, followed by the third ball [13].

Figure 3. Triflow.

Single ball flow-targeted incentive spirometer: A breathing tube is connected to a closed chamber (Figure 4). A full closure of this chamber allows the ball to rise easily at a 200 cc/sec inspiratory flow rate. A target flow can be set on the top dial by rotating the dial. The ball in the chamber does not rise unless the targeted flow is achieved by the patient.

Figure 4. Single ball flow-targeted incentive spirometer.

Pediatric flow targeted incentive spirometer: This variant (Figure 5) is specifically useful in pediatric, geriatric, or weakened patients with flow settings from 100 ml/sec to 600 ml/sec, virtually any patient can sustain the minimum inspiratory effort required for effective therapy.

Figure 5. Pediatric flow targeted incentive spirometer.

There are many other flow targeted devices, which work on a similar principle.

Target: In a flow targeted incentive spirometer, the patient tries to generate a predetermined flow. The patient is encouraged to maintain an end-inspiratory hold for 2-3 seconds [14]. In the triflow device, two out of three plastic balls should be raised and sustained for 2-3 seconds. The third ball indicates high flow and turbulence as well as acts as a control; hence it should not be raised. The patient is instructed to take a deep breath in such a way that, the ball stays at the highest for as long as possible. Some units might offer different flow rates; the therapist can change the flow rate to provide different levels of challenge.

Mechanism: The patient attempts to raise the floats through inspiratory flow created by negative intra-thoracic pressure, either with a quick or sustained deep breath. The slow sustained inspirations are emphasized, as they are more effective for lung expansion instead of fast inspirations. Slow inspiration improves collateral ventilation and reduces patient discomfort when performing post-operative breathing exercises. Apart from this, flow-targeted devices impose more work of breathing and increase the muscular activity of the upper chest [15].

How to use incentive spirometers?

Clear and precise instructions should be given along with a demonstration using a dedicated device.

Patient's position: The patient should be relaxed and in an upright sitting (Figure 6) or standing position, preferably on a chair or either side-lying position depending upon the affected area, which is to be targeted for the expansion.

Position of the incentive spirometer: The incentive spirometer has to be positioned upright, at the level of the eyes to see accurate volume and flow. The tubing should be straight to reduce the resistance. The patient should hold the spirometer handle with one hand and the mouthpiece in the mouth with the opposite hand, with lips sealed around the mouthpiece firmly.

Figure 6. Positioning of patient and spirometer.

Technique: The patient should be trained pre-operatively to facilitate learning. Post-operative pain may make learning a new technique difficult.

While doing inspiratory exercise with volume as well as a flow targeted spirometer, the patient is instructed to blow out first completely through the mouth *i.e.* exhale to Functional Residual Capacity (FRC) followed by a slow deep breath through the mouthpiece. The patient is advised to achieve the target and maintain an end-inspiratory hold without suffocation. In the case of the volume-targeted spirometer, the flow indicator should be maintained within the optimal flow limit, as marked over the incentive spirometer [16].

Expiratory exercises can be performed with the same device by holding it upside down. While doing the expiratory exercise the patient is instructed to take a deep breath through the nose followed by exhalation through the mouth into the mouthpiece. In the case of a volume targeted incentive spirometer, the patient is advised to lift the piston as much as possible without raising the flow indicator.

Breathing pattern should be maintained at the same time expansion of the lower chest should be emphasized for better results.

Monitoring: Throughout the procedure, the patient observes the spirometer while the physiotherapist monitors the patient's breathing pattern and technique learned. Direct supervision is not necessary once the patient demonstrates mastery of the technique. However, intermittent reassessment of the lung function and technique is essential to optimize the performance.

Monitoring the breathing pattern while using the volume as well as a flow targeted incentive spirometer, is important and should be communicated to the patient. Studies have shown that slow sustained inspiration used in volumetric incentive spirometry effectively promotes lung expansion rather than fast inspiration. The expansion of the lower chest should be emphasized rather than the use of the accessory muscles of inspiration which would encourage the expansion of the upper chest. Diaphragmatic movement is thought to be an important factor in the prevention of postoperative pulmonary complications [17].

Protocol

Several authors suggest using the device 5-10 breaths per session, at a minimum, every hour while awake which amounts to 100 times a day. The caregiver does not need to be present with each performance, and the patient should be encouraged to perform spirometer exercises independently.

There is a lack of evidence for a specific frequency for use of incentive spirometers; few clinical trials suggest the following protocols:

- Ten breaths every one to two hours while awake.
- Ten breaths, 5 times a day.
- Fifteen breaths every 4 hours.

After proper instruction and demonstration, the patient should be encouraged to perform incentive spirometry independently.

Maintenance of incentive spirometer: To maintain hygiene and prevent the entry of dust or foreign objects into the tubing the device should be kept covered, when not in use. To prevent cross-infection, the use of the device should be restricted to one person only. Patients should be advised to disconnect the mouthpiece from the tubing and clean it with water, dry it, and re-attached it after every use [18].

Selection of incentive spirometer: There is a difference in the mechanism of volume and flow-targeted incentive spirometer. A comparison of both types of incentive spirometers suggested that there is a physiological difference in the effect of these two devices. Flow targeted devices impose more work on breathing and increase the muscular activity of the upper chest. Volume targeted devices impose less work on breathing, encourage larger inspiratory lung volume, and improve diaphragmatic activity compare to a flow-targeted spirometer. In a recent study, it was observed that volume-targeted incentive spirometry has resulted in early recovery of both pulmonary function and diaphragm movement in patients who have undergone laparoscopic abdominal surgery. A randomized controlled trial by Amaravadi Sampath Kumar et al. found that flow and volume targeted incentive spirometry had demonstrable and comparative improvements in pulmonary function and exercise tolerance and can be safely recommended to patients undergoing open abdominal surgery as there were no adverse events recorded [19].

Special consideration: The presence of an open tracheal stoma or tracheostomy is not a contraindication but requires adaptation (like a universal connector or connecting tubes) of the spirometer. Those on oxygen can use a nasal cannula or an incentive spirometer that entrains oxygen. Even patients on a spontaneous mode of the ventilator can be trained with an incentive spirometer intermittently, if hemodynamically stable.

Evidence: The systematic review and meta-analysis done by Kerrie Sullivan et al. showed that the incentive spirometer alone is less likely to result in a reduction in the number of adult patients with PPCs, in mortality, in the hospital stay, following cardiac, thoracic, and upper abdominal surgery. Other systematic reviews also uphold this conclusion, by not supporting the use of incentive spirometers for decreasing the incidence of PPCs following cardiac or upper abdominal surgery. Paulo Nascimento et al., found no statistically significant differences between the participants receiving incentive spirometer compared to those receiving deep breathing exercises, and chest physiotherapy in the risk of developing a pulmonary condition or the type of complication. There was no evidence that an incentive spirometer is effective in the prevention of pulmonary complications.

Although these systematic reviews, meta-analyses, and reviews have concluded that, the incentive spirometer is not much effective; it remains widely used without standardization in clinical practice as there is low-quality evidence regarding the lack of effectiveness of incentive spirometer for the prevention of PPCs in post-operative

patients. The review by Nascimento et al., underlines the urgent need to conduct well-designed trials in this field.

Numerous studies support the use of the incentive spirometer in clinical practice to improve ventilation, and lung expansion, to prevent and reduce PPCs like atelectasis. Incentive spirometer facilitated a sustained deep breath. The same effect can be encouraged without the incentive spirometer but the use of the device often causes greater inhaled volume, a more controlled flow, and better compliance to practice as it gives visual feedback on the device. This visual feedback can be useful to assess a patient's inspiratory effort by measuring the inhalation volume. It can be used in rehabilitation as a favorable tool, as it is cheaper and easy to manage with no known side effects. It is simple to train and does not require assistance once a patient has learned how to use it properly [20].

The study by Amaravadi S Kumar et al. has shown that an incentive spirometer might improve pulmonary functions, as it encourages patients to take long, slow, sustained deep inspirations, which leads to maximal inspiratory volume and assist to maintain the patency of the smaller airways. Postoperative hypoxemia is reduced by using an incentive spirometer which provides low level resistance training to the diaphragm and minimizes fatigue thereby improving inspiratory muscle strength and enhancing lung inflation. Also, AACVPR guidelines support the use of the incentive spirometer in the pulmonary rehabilitation program.

Respiratory Muscle Training (RMT) Devices: Respiratory Muscle Training (RMT) can be defined as a technique that aims to improve the function of the respiratory muscles through specific exercises and might help to reduce dyspnea on exertion. RMT may consist of Inspiratory Muscle Training (IMT) Expiratory Muscle Training (EMT) or a combination of the two.

The respiratory muscles are unique among the skeletal muscles since they must work without sustained rest throughout life. However, respiratory and neurological conditions, electrolyte disturbances, blood gas abnormalities, intense weight loss, and cardiac decompensation, may affect these muscles. Weakness of the respiratory muscles is defined as a reduction in muscle contractility, resulting in the inability of the respiratory muscles to generate normal levels of pressure and airflow during inspiration and expiration. The reduction in respiratory muscle strength could compromise exercise performance. Thus, the implementation of interventions, which have the potential to increase the strength of the respiratory muscles and, consequently, improve exercise performance and functional capacity is indicated, since deconditioning is one of the most common preventable causes of morbidity and mortality.

RMT has the potential to improve the function of the respiratory muscles, which consists of repetitive breathing exercises against an external load. The protocols can be modified by the time, intensity, and/or frequency of the training. However, to obtain a training response, the muscle fibers must be overloaded, by requiring them to work for longer, at higher intensities, and/or more frequently, than they are accustomed to. To achieve adequate overload most training regimens, combine two or three of these factors. Furthermore, the adaptations elicited by the training depend upon the type of stimulus, to which the muscle is subjected. The high-intensity and short-duration stimuli tend to improve strength, and the low-intensity and long-duration stimuli tend to improve the endurance of the respiratory muscles.

Thus, when their fibers are overloaded, the respiratory muscles respond to training stimuli, by undergoing adaptations to their structure in the same manner, as any other skeletal muscles.

Indications:

- Primary indications are dyspnea and/or exercise intolerance.
- Respiratory conditions (such as asthma, bronchitis, emphysema, and COPD), neuromuscular conditions (such as a cerebral-vascular accident), or cardiac conditions.
- Subgroup of post-operative or geriatric patients.
- Specific conditions where either IMT has been shown to produce some clinically significant benefits or there is a theoretical rationale for IMT, based upon the presence of inspiratory muscle dysfunction, abnormal respiratory mechanics, producing a demand/capacity imbalance within the respiratory pump.
- Some specific physiological indicators of potential load-capacity imbalance of the respiratory muscles, and/or inadequate respiratory muscle function like reduced respiratory muscle strength, dyspnea, orthopnea, expiratory flow limitation, hyperinflation, reduced respiratory system compliance, elevated ratio of dead space to tidal volume (VD/VT), tachypnea, hypoxemia, hypercapnia, poor cough function, inability to breathe without the aid of mechanical ventilation.
- Sports training.
- Individuals with Fontan physiology condition.

Contraindications: Although evidence of IMT related adverse events is not present, there is a theoretical risk of barotrauma-related injuries. Accordingly, caution should be exercised in the following situations:

- A history of spontaneous pneumothorax.
- A pneumothorax due to a traumatic injury that has not healed fully.
- A burst eardrum that has not healed fully, or any other condition of the eardrum.

The sub-group of asthma patients with unstable asthma and abnormally low perception of dyspnea are also unsuitable candidates for IMT.

Types: Respiratory Muscle Training (RMT) devices enhance respiratory muscle strength, endurance, and exercise capacity. It is divided into two main categories Inspiratory Muscle Training (IMT) devices and Expiratory Muscle Training (EMT) devices.

Inspiratory Muscle Trainer (IMT)

IMT devices improve both inspiratory and expiratory muscle strength. They have two different modes, each for a specific use.

- Voluntary isocapnic hyperpnea, which enhances the inspiratory muscle endurance.
- Resistive inspiratory muscle training, which enhances the inspiratory muscle strength.

This mode has two types.

Pressure resistive IMT devices (PR-IMT): PR-IMT devices are usually handheld devices that incorporate a spring-loaded one-way valve that is impeded with different intensities, which opens to permit

airflow provided that a preset inspiratory pressure has been reached. The load is independent of airflow and may be set at a percentage of Maximal Inspiratory Pressure (MIP). The intensities can be adjusted by the resistive load knob varying from low to high. This encourages the patient to produce a set inspiratory force with every breath, which creates a training effect.

In addition, the normal mechanism of PR-IMT devices requires the initiation of negative pressure created by the subjects to overcome the load resistance. The effectiveness of these devices has been proved by Turner et al. by stating that, the PR-IMT devices lead to an improvement in Maximal Inspiratory Pressure (MIP), Maximal Expiratory Pressure (MEP), diaphragm mobility, and thickness. Several types of PR-IMT have wide ranges of features like muscle strengthening, endurance training, and improvement of the perception of dyspnea. Such devices can be used with different intensities like high, moderate, and low (Figure 7).

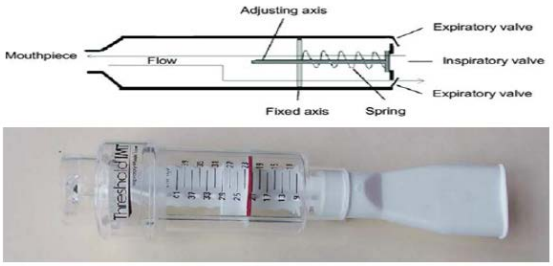

Figure 7. Pressure resistive IMT devices (PR-IMT).

This can be objectively documented by measuring the mean or Maximum Inspiratory Pressure (MIP) using a maximum pressure monitor device. A patient on a ventilator (Figure 8) can be successfully weaned off if MIP reaches a level of more than 30 cm of water.

Figure 8. MIP and MEP measurements and inspiratory muscle training on a ventilator (spontaneous mode).

Flow resistive IMT devices: A flow dependent device sets resistance by the inspiratory orifices of the various dimensions, but this load may be lessened by the patient taking slow breaths to reduce turbulence. These devices are less likely to provide a training effect but best are used for desensitization to breathlessness. These devices provide resistance during expiration similar to PEP masks.

PEP masks are often used as flow dependent inspiratory muscle trainers by attaching the resistance to the inspiratory port of the ventilator and can be used to prepare the patient for successful weaning by varying the expiratory pressures.

Flow resistive devices have two types, passive and dynamic.

Passive flow resistive device: It requires inhaling through a fixed orifice, which can be changed to increase the training load. The smaller the diameter, the higher the load required to overcome. However, one of the disadvantages that the flow resistive devices have is that they are affected by the inspiratory flow which is initiated by the subject. Thus, breathing patterns should be monitored during training when using these devices.

Dynamic flow resistive device: It requires inhaling through a variable orifice (Figure 9) within the breath which makes the dynamic flow resistive devices superior to passive devices.

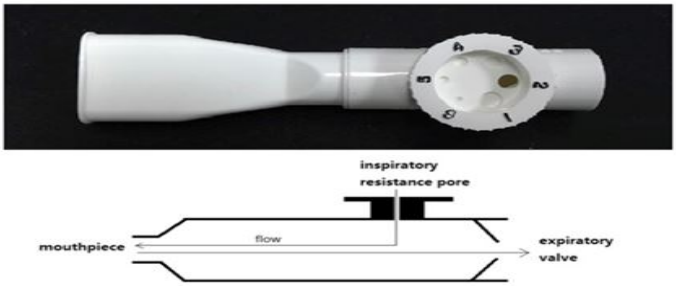

Figure 9. Dynamic flow resistive device.

Expiratory Muscle Trainer (EMT): In contrast to IMT, EMT devices (Figure 10) improve the strength of the expiratory muscles only. Strengthening the expiratory muscles is important for effective airway clearance. The construct and principle of EMT devices are similar to IMT except that the person is supposed to exhale in the device instead of inhale as in IMT. A set pressure by recoiling the spring ensures that the target expiratory pressures are reached.

Figure 10. Expiratory muscle trainer.

How to use the RMT device?

Clear and precise instructions should be given along with a demonstration using a dedicated device.

Discussion

Patient position

The patient is advised to sit in a comfortable position and put the nose clip so that all of the breathing is done through the mouth. Place the lips around the mouthpiece, making a good seal (Figure 11). RMT can be done in intubated patients (Figure 12) through endotracheal or tracheostomy tubes by connecting the RMT device with flexible tubing.

Device position

For the spontaneously breathing patient, the mouthpiece is held in the mouth with lips tightly sealed around it to ensure no leak. This device does not require the patient to see the device as there is no visual feedback like in the spirometer. The flow of air is possible only if the set pressure target is achieved with expiratory effort.

Figure 11. Patient using IMT Device.

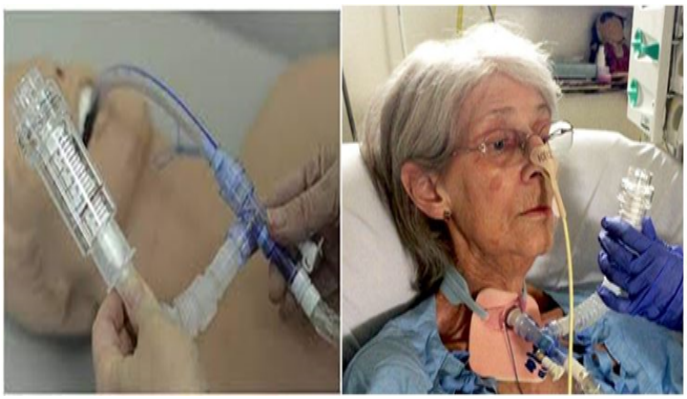

Figure 12. Inspiratory muscle training *via* endotracheal and tracheostomy.

Technique to use RMT device

The patient is instructed to take a deep breath and then exhale slowly at an inhalation to exhalation ratio of 1:3 or 1:4 (ensuring that exhalation is longer than the inhalation time). These steps are repeated until completing 30 breaths without the feeling of dizziness by pausing in between for normal breaths as required. The number of repetitions, load, training time, and resting time during the session is noted. To ensure proper understanding the procedure is explained verbally and a booklet of the instruction is provided, if possible.

Monitoring

The procedure should be demonstrated by the therapist to the patient and supervised till they learn. The breathing pattern is monitored during training while using these devices. Once the technique is mastered, patients can use this device by themselves without supervision. To ensure adherence, a diary can be maintained or a daily reminder can be set.

Maintenance

The maintenance of the RMT devices is similar to the incentive spirometer.

Protocol

For strength training, the target is generally 80% of MIP and for endurance training, it is 60% of MIP, but benefits have been found at 30% of the maximum. The level of resistance should cause the patient to become a little more breathless than usual without becoming silent or disturbed if the goal is to desensitize patients to breathlessness. The resistance should be adjusted such that the patient can tolerate it for 10 minutes. Patients should be at ease while inhaling strongly enough to overcome resistance. They should work at different ranges to prevent muscle fatigue while avoiding excess hyperinflation.

The duration of the training can be increased from about 5 minutes twice a day to about 15 minutes three times a day, with resistance increased fortnightly for the first 6 weeks and then monthly.

When IMT fits into the patient's schedule and the resistance is comfortable, adherence is reasonable. The principles of training such as alternate exercise with rest, avoiding distressing levels of fatigue (overtraining), and progress by increasing time and/or resistance should be followed.

Special consideration

If oxygen is needed while RMT training, a nasal cannula can be used.

Selection: IMT attempts to enhance respiratory muscle strength and endurance. Inspiratory resistive training uses devices that allow inhalation against resistance at a specific threshold. IMT may improve dyspnea and allow a patient to sustain a higher level of ventilation by favorably altering the ratio between the current inspiratory pressure generated and the maximal inspiratory pressure (PI/PI max) and by reducing compromising dynamic hyperinflation through a reduction in inspiratory time.

Evidence

Although RCT in 25 patients with COPD found no advantage, pilot research in 36 patients with COPD found that using IMT in combination with an exercise program led to better improvement in walk test distance than those who underwent exercise alone. IMT led to better improvement in cardiopulmonary exercise test parameters after an exercise program, according to another pilot trial including 42 patients. Given their shortcomings in important areas, the results of this study seem to be susceptible to bias. These results were not later repeated, in two RCTs with a minimal risk of bias that evaluated IMT as a supplement to exercise programs, IMT is not advised due to the inconsistent results and significant limitations of the research taken into consideration.

Although the British Thoracic Society 2013 guidelines do not support the routine use of the IMT in pulmonary rehabilitation, there is recent evidence that supports the use of the RMT in training. A systematic review and meta-analysis done by Beaumont et al. concluded that IMT using threshold devices improves inspiratory

muscle strength, exercise capacity, and Quality of Life (QOL), and decreases dyspnea. However, there is no added effect of IMT on dyspnea during Pulmonary Rehabilitation (PR) compared with PR alone in COPD patients. The systematic review done by Rocío Martín-Valero et al., examined levels of evidence and recommendation grades of various therapeutic interventions of IMT in people who have had a stroke. Benefits from varying degrees of resistance and force on the respiratory muscles are seen in this population. This review concluded that IMT is required to implement respiratory muscle training as a national health system service and to take into account its inclusion in the traditional neurological program. According to Stefanie Vorona et al. systematic review and meta-analysis, inspiratory threshold loading has been used in the majority of trials using IMT in critically sick patients. IMT is practical, well tolerated, and improves both inspiratory and expiratory muscle strength in critically ill patients. Future research will be necessary to confirm IMT's effect on clinical outcomes.

The case study was done on the 6 failure to wean patients and has shown that the Inspiratory Strength Training (IST) sessions may assist in the weaning of these patients from mechanical ventilators by several mechanisms. Decreased inspiratory muscle strength is often cited as a major factor contributing to prolonged mechanical ventilation. The possible explanations for the benefits from the IST include reversal of disuse atrophy affecting the muscles of respiration, altered neuromuscular dysfunction specific to inspiration, improvement in breathing patterns *(i.e.* slow, deep breathing versus rapid, shallow breathing), and nonspecific training effects. The IST was performed once a day, 6 to 7 times a week. Four sets of 6 to 8 breaths were completed every training day, with a 5 to 10 minute rest between sets to inhale. Treatments lasted from 30 to 50 minutes (including rest between sets). In conclusion, this case report illustrates how the use of IST with ventilator dependent patients may promote weaning, even in people who are terminally ill. The device used was the threshold IMT, which features a one-way, spring-loaded valve that allows patients to exhale with no resistance, but requires the patients to reach the preset load to inhale.

Conclusion

To reduce postoperative pulmonary complications physiotherapy plays a crucial role through pre-habilitation, post-operative care, and rehabilitation. The use of incentive spirometers and respiratory muscle training devices is an integral part of physiotherapy. Currently, there are many devices available in the market, which have been used in physiotherapy. This article focuses on making healthcare providers aware of the types, components, teaching techniques, and uses of such devices, to have optimal and specific benefits. Although the use of these devices is not mutually exclusive, the knowledge of these devices may help professionals to select the best device to be used. To select the most appropriate one, it is also necessary to consider the specific health condition, the nature of the impairments, and the purpose of training.

Recommendations

The following recommendations are made following the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) scoring system.

Incentive spirometry alone is not recommended for routine use in the preoperative and postoperative setting to prevent postoperative pulmonary complications (1B).

- It is recommended that incentive spirometry be used with deep breathing techniques, directed coughing, early mobilization, and optimal analgesia to prevent postoperative pulmonary complications (1A).
- It is suggested that deep breathing exercises provide the same benefit as incentive spirometry in the preoperative and postoperative setting to prevent postoperative complications (2C).
- Routine use of incentive spirometry to prevent atelectasis in patients after upper abdominal surgery is not recommended (1B).
- Routine use of incentive spirometry to prevent atelectasis after coronary artery bypass graft surgery is not recommended (1A).
- It is suggested that a volume-oriented device be selected as an incentive spirometry device (2B).

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