SPECIFIC INSPIRATORY MUSCLE TRAINING CAN IMPROVE THE OVERALL FUNCTIONALITY OF THE INSPIRATORY MUSCLES AND CONTIBUTES TO REDUCTION OF RESPIRATORY COMPLICATIONS

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VJEŽBE RESPIRATORNIH MIŠIĆA U RJEŠAVANJU RESPIRATORNIH TEGOBA

Sažetak

UVOD: Specifični inspiratorni trening mišića (IMT) može poboljšati funkciju inspiratornih mišića. POWERBreathe Kinect serija (POWERBreathe) je nedavno razvio IMT uređaj koji se pruža promjenjivi otpor putem elektronski upravljanog ventila (promjenjiv protok otpornog opterećenja). Za razliku od tradicionalno primijenjenih opterećenja, promjenjiv protok otpornog opterećenja poseban je izazov za inspiratorne mišiće u većim plućnim volumenima, a može dovesti do većih učinaka treninga. Razrada: Cilj ovog rada bio je sažeti osnovne činjenice i znanja temeljena na dokazima o IMT s promjenjivim otporom za najrelevantnije indikacije te raspraviti ove rezultate u kontekstu aktualne literature za grupu neuromuskularnih bolesti i skupinu opstruktivne plućne bolesti, kao i trenutnim saznanjima o "odvikavanju" iz invazivne mehaničke ventilacije u kontekstu fizičke aktivnosti. Rezultati meta analize prema Ferreira i sur., pokazali su da specifična IMT poboljšava snagu respiratornih mišića i ventilacijsku funkciju, i treba biti dodana u rehabilitaciju bolesnika s neurodegenerativnim bolestima. Nedavna studija Gosselink i sur. upućuje da je skupina ispitanika koji su provodili trening s 80% intenziteta MIP-a imali povećani vitalni kapacitet i ukupni kapacitet pluća. Nekoliko studija je također potvrdilo je da svakodnevno intermitentno inspiratorno opterećneje sa šest do osam kontrakcija ponavljanja u tri do četiri serije umjerenim do visokim intenzitetom je sigurno, te je poboljšalo inspiratornu mišićnu snagu. Studije su pokazale da opterećenje može biti manje optimalno u usporedbi s (elektronskom) suženim proto.otpornim opterećenjem. **ZAKLJUČAK**: Posebni IMT je siguran i učinkovit za pojedince s različitim bolestima. Studije i istraživanja pokazuju da se neke prilagodbe moraju uzeti u obzir za svaku grupu pacijenata. Osim toga, očekuje se da inspiratorni trening mišića smanji rizik od respiratornih komplikacija. Kada se u kliničkoj praksi provodi trening bolesnika s IMT, fizioterapeut treba aktivno sudjelovali u postizanju odgovarajućih obrazaca treninga.

KLJUČNE RIJEČI: Specifični inspiratorni trening mišića, slabost dijafragme, neuromuskularne bolesti, opstruktivne bolesti pluća, "odvikavanje" od invazivne mehaničke ventilacije.

Abstract

INTRODUCTION: Specific inspiratory muscle training (IMT) can improve the function of the inspiratory muscles. POWERBreathe Kinect Series (POWERBreathe- Int. Ltd, UK) is a recently developed IMT device that applies a variable resistance provided by an electronically controlled valve (variable flow resistive load). In contrast to the traditionally applied threshold loading, this variable flow resistive load is specifically challenging for the inspiratory muscles at higher lung volumes, and may lead to larger training effects. Discussion: The aim of this article was to summarise the basic facts and evidence based knowledge about IMT with variable resistance for the most relevant indications and to discuss these results in the context of current literature for the group of neuromuscular diseases and the group of obstructive lung diseases as well as current knowledge on „weaning" from invasive mechanical ventilation in the context of physical activity. Results of the meta analysis done by Ferreira et al, showed that specific IMT improved the strength of respiratory muscles and ventilatory function, and should be an adjunct to rehabilitation of patients with neurodegenerative diseases. A recent study done by Gosselink et al reported that a group of subjects who trained at 80% intensity of MIP experienced increased vital capacity and total lung capacity but it has it has it's limitations. Several studies also confirmed that daily intermittent inspiratory loading with six to eight contractions repeated in three to four series at moderate to high intensity was safe, it improved inspiratory muscle strength and weaning success in patients with difficult weaning. Studies have shown that threshold loading might be less optimal compared with (electronic) tapered flow-resistive loading. Conclusion: Specific IMT is safe and effective for inidividuals with different diseases. The studies and researches indicated that some adjustment have to be taken into consideration for each group of patients. In addition, inspiratory muscle training is expected to reduce the risk of respiratory complications. when training patients with IMT in a clinical setting, therapists should be actively engaged to emphasize the correct training pattern.

KEYWORDS: Specific inspiratory muscle training, diaphragm weakness, neuromuscular diseases, obstructive lung diseases, „weaning“ from invasive mechanical ventilation.

Introduction

Specific inspiratory muscle training (IMT) can improve the function of the inspiratory muscles (1,2,3). According to literature and clinical experience, there are three established methods of inspiratory muscle training: 1.) (variable flow) resistive load, 2.) threshold load and 3.) normocapnic hyperpnea (4). POWERBreathe Kinect Series (POWERBreathe- Int. Ltd., UK) is a recently developed IMT device that applies a variable resistance provided by an electronically controlled valve (variable flow resistive load). In contrast to the traditionally applied threshold loading, this variable flow resistive load is specifically challenging for the inspiratory muscles at higher lung volumes, and may lead to larger training effects especially for COPD patients (1,2). Besides these potentially beneficial characteristics of the applied load, another advantage of the device is the ability to store home-based training data for up to 40 sessions. Continuous registrations of pressure and flow at 500 Hz provide data on the external work of breathing and enable the verification of quantity as well as quality of unsupervised training sessions (1).

Background

The diaphragm is composed by only 55% of type I fibers (5), but because it works 24 hours per day, seven days a week, it has been thought that the diaphragm should receive endurance training (30% of MIP) to improve its performance(6). However, it has been described, that during situations which leads to increased activity of inspiratory muscle recruitment, a change occurs with Type I to Type II fibers(7). It is also important to understand, that on the other hand, SCM muscle activation is only required during high ventilation levels in normal persons (8). the respiratory therapists have to emphasise the role of primary breathing muscles over the accessory breathing muscles.

Although IMT can improve the overall functionality of the inspiratory muscles, IMT may become problematic if it induces a change in the roles between primary breathing muscles and accessory muscles in accordance with the training intensity. In addition, by assigning inappropriate training intensity for a subject who has weak respiratory function, overactivation of the accessory muscles may occur owing to compensation from the inspiratory muscle. These situations may occur when the resistance to airflow generated by the threshold IMT device creates excessive resistance, resulting in the conversion to a costal respiratory type through the use of the neck muscles (1,2). Furthermore, the decline observed in the relative activation of the diaphgram in accordance with increased training intensity would be due to the researchers' inability to actively prevent or consider compensation in the subjects.

Therefore, when training patients with IMT in a clinical setting, therapists should be actively engaged (verbally or through feedback) to emphasize the importance of practicing mixed predominance of thoracic expansion over abdominal expansion during inspiratory movements, or the costal respiratory pattern and abdominal respiratory pattern (9). Furthermore, IMT should be carried out with the application of deep slow breathing to prevent overactivation of the accessory inspiratory muscles. Finally, it is recommended that therapists try their best to minimize compensation by providing proper training at a suitable intensity through accurate identification of the patient's pulmonary functions.

Discussion

The aim of this article was to summarise the basic facts and evidence based knowledge about IMT with variable resistance for the most relevant indications and to discuss these results in the context of current literature for the group of neuromuscular diseases and the group of obstructive lung diseases. Last but not least, we summarize current knowledge on „weaning“ from invasive mechanical ventilation in the context of physical activity.

Neuromuscular/neurodegenerative diseases

Among neurodegenerative diseases, multiple sclerosis (MS) and amyotrophic lateral sclerosis (ALS) have a high incidence and high rate of disability (10). Although they have different causes, these diseases affect the skeletal muscles, including the respiratory muscles (11). MS is a demyelinating chronic, neurological disease with progressive degeneration in the nervous system (12). ALS is also characterized by the degeneration of motor neurons, causing atrophy and loss of muscle mass with progressive difficulty in movements, including atrophy and muscle mass loss of the respiratory muscles (11,12).

The weakness of respiratory muscles, predominantly the diaphram, is a characteristic of individuals with advanced neurodegenerative diseases and may result in pulmonary dysfunctions, such as difficulty in clearing secretions (inability to cough efficiently), repeated episodes of pneumonia, which is the main cause of death in this population (13,14).

Furthermore, the ventilatory function is diminished, leading to a restrictive feature (10), and possibly, these aspects also relate to lower functional capacity in this group of patients. Thus, training of respiratory muscles (specificly IMT) gives these patients a better quality of life (15-17).

Results of the meta analysis done by Ferreira et al (18), showed that specific IMT improved the strength of respiratory muscles and ventilatory function, and should be an adjunct to rehabilitation of patients with neurodegenerative diseases. The authours of the meta-analysis suggest that the load or intensity training should be greater than 30% MIP(18).

COPD

Factors that impair the contractile properties of the respiratory muscles for COPD patients (e.g. the pattern of tension development, functional weakening and fatigue) have the potential to increase the intensity of dyspnoea, while factors that improve the contractile properties of these respiratory muscles (e.g. IMT) have the potential to reduce the intensity of dyspnoea. In patients with obstructive pulmonary disease, functional weakening of the inspiratory muscles in response to dynamic lung hyperinflation appears to be a central component of dyspnoea (19).

Specific IMT can have a positive effect on pulmonary function, work capacity, power output, exercise performance, and recovery times (20, 21). On the other hand, the increase in the strength of the respiratory muscles through IMT can be explained by a mechanism involving an improved neuromuscular recruitment pattern (2,3,21). A recent study reported that a group of subjects who trained at 80% intensity of MIP experienced increased vital capacity and total lung capacity, which indicates that the inspiratory muscles had an increased ability to expand the thorax (21). However, the problem with these findings is that a greater contribution is needed from the upper thorax and neck muscles when the lung volume increases, and neck muscle activity will increase as the training intensity of IMT increases (3, 12).

Intensive care unit (ICU)-acquired weakness, ICUAW

Skeletal muscle dysfunction acquired during critical illness (intensive care unit (ICU)-acquired weakness, ICUAW) plays an important role in clinical outcomes such as liberation from mechanical ventilation, ICU length of stay, hospital length of stay, physical function and mortality (22,23). ICUAW is a common complication of critical illness with a complex aetiology (24) affecting both limb muscles as well as respiratory muscles. The decline in muscle mass is approximately 2%–4% per day in the first week of ICU stay (25,26). Loss of limb muscle mass is more pronounced in patients with multiple organ failure (25) while a rapid decline in diaphragm muscle strength and thickness is associated with sepsis (27) and low diaphragm contractile activity (26). Strategies to prevent or treat ICUAW are scarce and mostly focused on the treatment or reduction of risk factors associated with ICUAW (sepsis, hyperglycaemia, catabolism, neuromuscular blockers and corticosteroids) (24). In addition, immobility and inactivity contribute considerably to muscle atrophy: 'mechanical silencing' has been identified as an important contributor to the loss of contractile properties (28). Therefore, reversing inactivity of the muscle should have the potential to prevent, reverse or ameliorate muscle wasting.

It remains unclear as to why the respiratory muscles are only very rarely addressed in these programmes. Aproximately 15%–20% of patients fail successful liberation from mechanical ventilation (29). Inadequate ventilatory drive, increased work of breathing and weakness of the respiratory muscles are likely to contribute to weaning failure (30). The inability to breathe spontaneously relates to an imbalance between load on the respiratory muscles and the capacity of the respiratory muscles (31).

Studies confirmed that daily intermittent inspiratory loading with six to eight contractions repeated in three to four series at moderate to high intensity was safe, it improved inspiratory muscle strength and weaning success in patients with difficult weaning (32). Studies proved that threshold loading might be less optimal compared with (electronic) tapered flow-resistive loading (such as POWERBreathe Kinect Series (POWERBreathe- Int. Ltd, UK) (1,33,34). One of the main challenges of studies is that patients who might benefit from the intervention are oftentimes not sufficiently able to participate in the training sessions.

The time to measure the IMT effect is of a high importancy. Classical studies showed that is necessary at least ten days to increase strength in the limb muscles with minimal clinically important difference (1,20). This is very similar to inspiratory muscles that are necessary at least fourteen days to have improvement on strength. This early increasing on strength is related to neurological adaptation, hypertrophy starts to occur only from 20 day (1,2,20).

POWERBreathe Kinect Series (POWERBreathe - Int. Ltd, UK) an electronic kinetic device with feedback software is able to help respiratory therapists to understand what is happening with patients during their raining. This device provides automatically processed information on external inspiratory work. Moreover, power and breathing patterns during loaded breathing tasks is shown, thus the onset of fatigue can be detected earlier.

POWERBreathe Kinect Series was externally evaluated by Belgian researchers and they concluded that the Kinect technology provides automatically processed and valid estimates of physical units of energy during loaded breathing tasks (1).

Another great advantage of this kind of technology is the capacity of precise load adjustment (1 cmH2O per 1 cmH2O) reaching 3 to 200 cmH2O. Beyond that, the device can adjust the load dynamically, imposing higher load at the beginning of inspirations and lower load close to vital capacity. Thus, a greater range of motion can be reached improving the effectiveness of the training.

Many evidences point out that a high intensity training with loads ≥ 50% of MIP in 5 to 6 sets, aiming to reach thirty breathes, one or twice a day, seven days per week is a suitable protocol to improve performance of the diaphram.

Conclussion

Specific IMT is safe and effective for inidividuals with different diseases. Several studies indicated that some adjustment have to be taken into consideration for each group of patients. In addition, inspiratory muscle training is expected to reduce the risk of respiratory complications. when training patients with IMT in a clinical setting, therapists should be actively engaged to emphasize the correct training by practicing mixed predominance of thoracic expansion over abdominal expansion during inspiratory movements, or the costal respiratory pattern and abdominal respiratory pattern.

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