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Review Article

Physiotherapy Section

Effect of Inspiratory Muscle Training on Cardiovascular Fitness and Falls Prevention in Elderly Smokers: A Narrative Review

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ABSTRACT

Smoking and aging both increase the risk of falls in older adults by causing deterioration in cardiovascular and respiratory function. Strengthening and enhancing the function of respiratory muscles through Inspiratory Muscle Training (IMT) has been demonstrated as a viable intervention. The present review examines the potential advantages of IMT for cardiovascular fitness and fall prevention, particularly focusing on the vulnerable group of senior smokers. Evidence from Randomised Controlled Trials (RCTs) investigating the effects of IMT on cardiovascular outcomes and fall prevention in older smokers is reviewed. The review aims to critically assess the methodological quality and clinical relevance of the existing research by following the Scale for the Assessment of Narrative Review (SANRA) guidelines. Literature from searches on Web of Science, PubMed, and Scopus was analysed. The study includes articles published between 2014 and 2025, in order to ascertain the role of physical therapists in sustainable global health initiatives. Keywords related to "Cardiovascular fitness," "Elderly," "Falls Prevention," "IMT," and "Smoking" were optimised using Boolean operators. The included RCTs show that IMT results in statistically significant increases in inspiratory muscle strength. While improvements in core stability contributed to a reduced risk of falls, enhanced diaphragmatic function and oxygen uptake were associated with better cardiovascular performance. Although the findings are encouraging, they should be interpreted cautiously due to variations in participant characteristics, intervention duration, and outcome assessments. The current review concludes that cardiovascular fitness and IMT can reduce the incidence of falls in older smokers.

Keywords: Aged, Dyspnoea, Physical fitness, Tobacco smoking

INTRODUCTION

The IMT is a program designed to enhance the functioning of the diaphragm and other inspiratory muscles, allowing for more effective respiration and improved overall performance. Essential outcome measures determine the physiological and functional impacts of IMT on cardiovascular fitness and fall prevention in older smokers, including Maximum Inspiratory Pressure (MIP), Maximum Expiratory Pressure (MEP), diaphragm thickness, diaphragm mobility, dyspnoea, and functional performance tests such as the 6-Minute Walk Distance (6MWD), Timed Up and Go (TUG), and Five Times Sit-to-Stand (FTSST) [1-3]. These measures provide invaluable insights into the cardiovascular, neuromuscular, and respiratory changes associated with IMT and demonstrate how improvements in respiratory function lead to better physical performance and a reduced risk of falls [4,5].

For older smokers facing the effects of aging on respiratory muscle performance and the deteriorations caused by smoking, IMT can significantly enhance respiratory muscle strength, as reflected in improved outcomes in MIP and MEP. An effective example of assessing the impact of IMT among elderly smokers is its role in alleviating stress on respiratory muscles, leading to subsequent improvements in treatment schedules [6].

A study by de Alvarenga GM et al., compared the outcome of IMT in 16 elderly women and found a 38% improvement in MIP at the end of 20 IMT sessions. This effect was accompanied by considerable training-related improvement in inspiratory muscle strength [6]. In the study by Aslan et al., (2013), IMT was administered to patients with neuromuscular disease over a three-month period, and it was observed that both MIP and MEP demonstrated significant increases, similar to findings in larger populations [7]. Gosselink R et al., found that baseline muscle strength influenced IMT outcomes [8]; patients with significant inspiratory muscle weakness showed better responses, indicating a correlation between initial strength levels and the efficacy of training. Turner LA et al., in their study, supported this association by demonstrating that IMT prolonged exercise tolerance, reduced dyspnoea, and increased MIP, thereby expanding the therapeutic applications of IMT [9].

Diaphragm thickness and diaphragm mobility: Structural changes contributing to the therapeutic relevance of IMT also include increased thickness and mobility of the diaphragm, reflecting enhanced functional capacity. IMT improves both diaphragm thickness and mobility, thereby advancing respiratory performance in the elderly. The study by Seixas MB et al., through a systematic review, revealed that diaphragm thickness significantly increased following IMT, as identified through ultrasonography [10]. An increase of up to 11% in diaphragm thickness was observed, emphasising the value of such noninvasive assessments. Souza H et al., supported these findings by demonstrating increased diaphragm mobility and thickness, establishing that IMT produces both structural and functional effects on diaphragm characteristics [11]. The study by Sari F et al., showed that IMT positively influenced diaphragm thickness and mobility among patients with systemic lupus erythematosus. Following training, diaphragm thickness increased by approximately 14%, confirming that IMT is effective in promoting diaphragm hypertrophy even in the presence of chronic diseases [12].

In studies focusing on lumbar stability following diaphragm training, an increase in stabiliser muscle activity was noted (in contrast to purely respiratory tasks), as reported by Finta R et al., (2018) [13]. Adaptations in diaphragm structure indicated enhanced functional capacity, as well as improvements in respiratory performance and core stability. It was found that diaphragm hypertrophy induced

through IMT extends beyond respiration, resulting in broader musculoskeletal benefits [13].

Dyspnoea (Shortness of Breath): Inspiratory Muscle Training (IMT) decreases dyspnoea in older smokers, enhancing respiratory efficiency and exercise capacity. Inspiratory muscle weakness is occasionally associated with an increased perception of dyspnoea, which does respond to IMT. Yuenyongchaiwat K et al., found that elderly smokers had a mean Maximum Inspiratory Pressure (MIP) of 68.32 cm H_2O, revealing inspiratory muscle weakness correlated with higher dyspnoea severity [14].

As shown in the systematic review conducted by Mota JC et al., IMT has been demonstrated to elevate inspiratory muscle strength and endurance levels, significantly reducing reports of dyspnoea among individuals with Chronic Obstructive Pulmonary Disease (COPD) [15]. Enhanced exercise endurance further emphasises the importance of IMT in the clinical management of respiratory dysfunction. The meta-analysis by Han B et al., ensured that IMT improved MIP and reduced dyspnoea, positively impacting overall respiratory efficiency in elderly individuals and smokers [16].

Functional Performance Measures (6MWD, TUG, FTSST): The IMT enhances functional performance, thereby improving mobility and endurance among elderly individuals with respiratory impairments. These advantages are evident in specific functional tests, such as the Timed Up and Go (TUG), Five Times Sit to Stand (FTSST) assessment, and the 6-Minute Walk Distance (6MWD) [1-3]. IMT increases inspiratory muscle activity, which translates to improved exercise capacity and physiological performance [17].

Cordeiro ALL et al., (2016) analysed the effects of IMT in post-cardiac surgery patients, demonstrating improved functional capacity, reduced postoperative complications, and shortened hospital stays. Although functional performance was not the primary focus of the study, the findings suggested positive indirect benefits of IMT on mobility outcomes [18]. Jung NJ et al., [19] examined the effects of IMT in stroke patients, noting that one patient underwent 12 weeks of IMT and showed a 19% improvement in 6MWD, indicating enhanced aerobic capacity and ability. Jung NJ et al., (2017) recorded enhanced 6MWD among COPD patients, with measurements increasing from 352.3 metres to 363 metres, confirming the effectiveness of IMT in enhancing exercise tolerance [19].

According to Wang K et al., (2017), the study demonstrated that IMT resulted in significant improvements in exercise capacity compared to usual care in stable COPD patients, providing further evidence of IMT's role in a respiratory rehabilitation setting [20]. Research on COPD patients by Mehani SHM (2017) showed that increases in functional capacity were associated with an augmentation of MIP, which directly enhanced 6MWD outcomes [21]. Findings by Gosselink R et al., (2011) indicated that patients with inspiratory muscle weakness exhibited greater functional improvements following IMT, thus supporting the connection between increased inspiratory muscle capability and improved endurance [8].

Cardiovascular fitness and oxygen utilisation: IMT enhances cardiovascular fitness and oxygen utilisation in individuals with diminished respiratory abilities, which in turn improves aerobic capacity and exercise performance. In the absence of IMT, weak respiratory muscles impair the body's ability to transport and utilise oxygen during physical activity. According to Bhatnagar A et al., (2020), patients with chronic heart disease undergoing IMT treatment exhibited a significant 9.2% increase in peak oxygen uptake (VO_2 peak). These results demonstrated that the muscles utilised more oxygen during exercise, and the cardiovascular system responded more effectively to physical activity [22].

The influence of Inspiratory Muscle Training (IMT) on the human body was studied by Fan Y et al., (2024) and Ghosh D et al., (2020). They concluded that the reinforcement of inspiratory muscles led to an increase in lung volume and ventilation efficiency, which, in turn, elevated the uptake of oxygen during activities [23,24]. Ghosh D et al., (2020) emphasised variability in the responses to training, noting that although aerobic and interval training improved the strength of the inspiratory muscles, the training responses were not always correlated with maximum oxygen consumption [23].

Huzmeli I and Ozer AY (2023) discovered that IMT positively affected cardiovascular and pulmonary functionality when combined with aerobic exercise. Moreover, the cardiovascular effectiveness of IMT was enhanced by the relationship between improved left ventricular capability and increased aerobic performance. A systemic effect of IMT was noted by Dipp T et al., (2020), who compared the results of IMT in patients with chronic kidney disease undergoing haemodialysis. They found that IMT enhanced exercise tolerance and perfusion of peripheral muscles, augmented inspiratory muscle strength, and lessened inspiratory muscle metaboreflex [25,26].

The findings of a systematic review by Adamopoulos S et al., (2014) confirmed the utility of IMT in aerobic training programs; patients with chronic heart failure showed improvements in exercise capacity and oxygen uptake. The data indicated different outcomes among patient groups based on the initial weakness of inspiratory muscles and the extent of the disease, which influenced the response to IMT [27].

The aim of the present narrative review was to assess the effect of IMT on cardiovascular fitness and fall prevention in elderly smokers.

A search for relevant literature was conducted using PubMed, Web of Science, Scopus, and Google Scholar with the search terms "Aged," "Dyspnoea," "Falls," "Physical Fitness," and "Tobacco Smoking." Articles screened for the narrative review were assessed according to the standardised Scale for the Assessment of Narrative Review (SANRA) guidelines [28]. The inclusion criteria were full-text articles published in English between 2014 and 2025 with a SANRA score of more than 6. Exclusion criteria included full-text articles with a SANRA score of less than 6, those published in a native language other than English, or any articles for which the full text was unavailable.

The results of six high-quality RCTs indicated that IMT and fall prevention positively affected the cardiovascular fitness of elderly smokers. The studies employed strict methods to measure key outcome measures, including dyspnoea, Maximum Expiratory Pressure (MEP), pulmonary function, Maximum Inspiratory Pressure (MIP), Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV), abdominal muscle activity, diaphragm mobility and thickness, and functional performance. The findings showed improvement in all functional parameters within durations of four to eight weeks. A summary of the studies included in the narrative review is listed in [Table/Fig-1] [29-34].

Author(s) and year	Device used	Focus area	Population	Outcome measures	Findings
Jung HJ et al., (2017) [29]	Spiro Tiger® (for FBE), Balloons (for BBE), Cardio Touch 3000S (for PFT), Pocket EMG (for muscle activity)	Pulmonary Function and Rectus Abdominis Muscle Activity	Elderly smokers	FVC, FEV1, rectus abdominis activity	FVC improved significantly EMG activity increased
Pişkin NE et al., (2023) [30]	Power Breathe Plus (blue model), MIR Spiro lab Spirometer, ironman k5 inspiratory muscle trainer	Respiratory functions and muscle strength	Smokers and non-smokers	FVC, FEV1, MIP, MEP	FVC: ↑11.8% (smokers), FEV1: ↑13.1% (smokers), MIP: ↑29.6%, MEP: ↑19.8%

Jun H Ju et al., (2015) [31]	Spiro Tiger® (for FBT), Balloons (for BBT), CardioTouch 3000S (for PFT)	Pulmonary function improvement in elderly smokers	Elderly smokers	FVC, FEV1	FVC ↑8.7% (BBT), ↑10.4% (FBT); FEV1 ↑5.8% (BBT), ↑7.6% (FBT)
Bostanci O et al., (2019) [32]	Power®Breathe Classic (IMT), MicroRPM (MIP/MEP), CPFS/D USB spirometer	Respiratory muscle strength and pulmonary function	Healthy male smokers	FVC, FEV1, MIP, MEP	FVC ↑7.4%, FEV1 ↑7.1%, MIP ↑32.4%, MEP ↑20.3%
Al Taweel M et al., 2024 [33]	Tapered Flow Resistive Loading (TFRL) device, portable handheld manometer, spirometer	Inspiratory muscle strength, pulmonary function, dyspnoea	Adult smokers	MIP, FVC, FEV1, PEFR	MIP ↑26.8%, FVC ↑5.6%, FEV1 ↑6.9%, PEFR ↑6.1%
Khyati S et al., (2020) [34]	Threshold IMT device, incentive spirometer	Functional ability and pulmonary function following surgery	chronic smokers & non-smokers	FVC, FEV1, 6MWD, MIP, MEP	Pre-post values shown improvement, specific % not given (protocol study)

[Table/Fig-1]: Included RCT studies outcome measures and findings [29-34].

DISCUSSION

The study aimed to gather recent literature on the application of Inspiratory Muscle Training (IMT) as a therapeutic intervention to improve cardiovascular fitness and reduce the risk of falls in the elderly smoker population. A total of six relevant articles were identified for this investigation. The Randomised Controlled Trials (RCTs) included in the studies showed that IMT, combined with multi-treatment approaches, demonstrates positive results on cardiovascular fitness, fall prevention, and overall health in elderly smokers. Improvements have been routinely observed in diaphragm thickness, Maximum Expiratory Pressure (MEP), Maximal Inspiratory Pressure (MIP), pulmonary function, lung capacity, and functional measures such as the Timed Up and Go (TUG), Five Times Sit-to-Stand Test (FTSST), and Six-Minute Walk Distance (6MWD).

Respiratory muscle strength and diaphragm function: Strong respiratory muscles, particularly the diaphragm, are essential for efficient breathing and overall pulmonary function. The diaphragm, the primary inspiratory muscle, produces up to 70% of the tidal volume during silent breathing. However, both the diaphragm and accessory respiratory muscles in smokers and the elderly can be weakened by age-related muscular atrophy and prolonged exposure to harmful stimuli. This results in decreased inspiratory capacity and mechanical inefficiency. Bostanci O et al., and At Taweel M et al., used threshold or tapered flow resistive devices to improve diaphragm function. Piskin NE et al., and Jun H ju et al., showed decreased respiratory effort and improved oxygenation by employing mechanical devices and balloon-blowing activities [30-33].

Dyspnoea and functional performance: According to these studies, breathing capacity improved in older individuals through workouts that included balloon blowing and feedback breathing (Jun HJ et al., 2016; Jun H ju et al., 2015). Increased lung capacity reduces dyspnoea, as indicated by Al Taweel M et al., (2024) using an enhanced modified Borg scale rating [29,31,33]. The Six-Minute Walk Test (6MWT) is frequently used to assess functional performance, which is directly linked to these respiratory benefits. According to Khyati S et al., (2020), frail elderly individuals with greater respiratory function after surgery had fewer complications. IMT reduces dyspnoea and strengthens the inspiratory muscles [34].

Implications for cardiovascular fitness: The IMT increases Forced Expiratory Volume (FEV) and MIP, as shown by Bostanci O et al., and Al Taweel M et al., (2024). It also improves oxygen uptake, maintains heart rate during exertion, and enhances exercise tolerance. IMT improves pulmonary health and cardiovascular fitness in elderly smokers [32,33]. Additionally, Khyati S et al., (2020) suggested that the use of breathing exercises in preoperative and postoperative care may indirectly improve cardiovascular outcomes by promoting early mobilisation, lowering the risk of deconditioning, and enhancing functional independence [34].

Implications for fall prevention: The combined effects of fatigue, poor balance, and muscle weakness make falls a major concern for older adults, particularly those with chronic respiratory conditions. Although not a traditional balance intervention, IMT increases functional capacity, gait endurance, and overall stability, all of which help to reduce falls. Research participants demonstrated improvements in postural control, abdominal muscle activation, and vital capacity, according to Jun HJ et al., (2016) and Jun H ju et al., (2015). Enhanced abdominal muscle activation improves trunk stability, which helps to decrease the number of falls and enhances postural control in elderly smokers [29,31].

CONCLUSION(S)

The narrative suggests that IMT enhances inspiratory muscle strength, as indicated by the included RCTs, which show improved cardiovascular performance. IMT decreases dyspnoea and also increases MEP, improves FEV, and enhances abdominal muscle activation and diaphragm thickness. This results in increased physical independence, lower complications, and improved quality of life in elderly smokers. While increases in core stability help lower the risk of falls, improvements in diaphragmatic function, respiratory strength, and overall functional performance are also evident.

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