

ORIGINAL ARTICLE

Effects of graded motor imagery on fear of movement, pain, and rehabilitation in patients with kinesiophobia after video-assisted thoracoscopic surgery for lung cancer: A randomized controlled trial

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Abstract

Objective: This study aimed to evaluate the effects of graded motor imagery (GMI) on fear of movement, pain, and rehabilitation in patients with kinesiophobia after video-assisted thoracoscopic surgery (VATS) for lung cancer.

Methods: Fifty-eight participants with kinesiophobia after VATS were randomly assigned into two groups: one receiving usual care (the control group) and the other receiving usual care plus GMI (the GMI group). The GMI was delivered in three stages: left/right limb identification, motor imagery, and mirror therapy delivered by two researchers every afternoon starting on the first postoperative day, once a day for about 40 min, at least twice. Level of fear of movement, pain-related patient-reported outcomes (PROs), rehabilitation exercise participation, and peak expiratory flow (PEF) were compared between the two groups.

Results: Twenty-seven eligible participants were included in the GMI group and 29 in the control group. Compared to the reports on the first postoperative day, the participants who received GMI reported at discharge significant reductions in kinesiophobia, intensity of worst pain and least pain, and interference of pain with activities and emotions, and increases in rehabilitation exercise participation and PEF than those in the control group ($p < 0.05$). An unexpected finding was a reduced surgery-to-discharge interval in the patients who received GMI (almost a day earlier than those in the control group).

Conclusion: GMI can reduce fear of movement, improve pain-related PROs, and increase rehabilitation exercise participation and PEF for lung cancer patients with kinesiophobia after VATS.

The study was registered at the Chinese Clinical Trial Registry (ChiCTR2300072612).

KEYWORDS

graded motor imagery, kinesiophobia, lung cancer, pain-related patient-reported outcomes, peak expiratory flow, video-assisted thoracoscopic surgery

Xinyuan Zhang and Xiaohong Zhang contributed equally to this work.

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INTRODUCTION

Pain is common and can be intense after operations, especially major ones like video-assisted thoracoscopic surgery (VATS) which has been widely used in lung cancer resection [1]. The incidence of pain in patients on the first day after VATS for lung cancer can be as high as 100% [2]. Respiratory and limb function exercises are crucial for the rehabilitation of patients after VATS. However, severe postoperative movement-evoked pain from activities such as deep breathing, effective coughing, and limb movements can exacerbate patients' fear of movement. Unrelieved movement-evoked pain can impede healing, restoration of function, and recovery [3].

In the fear-avoidance model, there are two extreme responses towards postoperative pain in different individuals, an "avoidance" behavior and a "confrontation" behavior [4]. Patients who exhibit "confrontation" behavior may gradually recover physical functions and social activities as the pain subsides, while those who display "avoidance" behavior may experience exacerbated pain because they restrict their movements due to fear of pain. For instance, patients with "avoidance" behavior suffering from postoperative pain after VATS would avoid abdominal breathing, effective cough, or arm lift due to the fear that such respiratory and limb rehabilitation exercises could worsen their pain, while patients with "confrontation" behavior after VATS would not do so. The negative interpretations of pain could provoke fear of movement and create a vicious cycle of avoidance, negative effects, and impairment, thereby leading to the formation of kinesiophobia [5].

Kinesiophobia, a symptom characterized by "the fear of movement as a result of a feeling of susceptibility to pain or reinjury", plays a mediating role between pain and physical activity, exacerbating patients' cognitive biases towards pain during movement [6]. Our previous study showed that more than one-third of the patients undergoing VATS suffer from kinesiophobia [7]. One scoping review suggested that kinesiophobia leads to adverse health outcomes such as reduced recovery, prolonged hospital stays, and decreased quality of life in patients after cardiac surgery [8]. As there is no report on the effect of kinesiophobia in lung resection patients, research on intervention strategies for postoperative kinesiophobia to promote early recovery is urgently needed.

Clinical studies report that graded motor imagery (GMI) is an effective strategy to transform the "avoidance" behavior in patients with kinesiophobia into "confrontation" behavior, promoting their activity and contributing to postoperative recovery. Continuous stimulation of the intercostal nerves by the chest tubes in patients after VATS exacerbates pain intensity and affects the patient's respiratory function and limb

Highlights

- For lung cancer patients with kinesiophobia after video-assisted thoracoscopic surgery (VATS), graded motor imagery (GMI) is an effective strategy to reduce fear of movement, improve pain-related patient-reported outcomes, and enhance rehabilitation.
- GMI can be integrated into routine rehabilitation care in clinical settings to help improve postoperative outcomes for lung cancer patients with kinesiophobia.

rehabilitation exercise. Patients receiving GMI intervention do not need to physically move their affected limbs, thereby reducing the perceived correlation between pain and activity. A qualitative study showed that GMI improves orofacial pain-related emotions and increases motivation in participating in rehabilitation exercises [9]. GMI has also been used in patients after surgery for distal radial fracture, surgery for post-traumatic elbow stiffness, and total knee arthroplasty, to reduce postoperative pain intensity and fear of movement and to improve function [10–12]. However, information is lacking about the efficacy of GMI in patients with kinesiophobia after VATS for lung cancer.

GMI consists of three stages in sequence: left/right limb discrimination, motor imagery, and mirror therapy. Each stage of GMI affects different areas of the central nervous system, promoting the reorganization of the sensory and motor cortices [13]. Left/right limb discrimination stimulates the participants to engage in invisible motor imagery by presenting images of limbs from different angles, activating the left/right discrimination areas of the brain cortex, and avoiding the association of pain perception during motor imagery [14]. The cognitive process of distinguishing left/right in images indirectly reflects the patient's ability to visualize and plan physical movements, a key aspect of motor imagery ability [15]. Motor imagery encourages the participants to imagine breathing and limb rehabilitation exercises and alleviate their fear of postoperative movements. It is reported that mirror therapy could reduce shoulder pain and disability in women following a mastectomy [16]. Through visual feedback during unilateral, unaffected limb movement, mirror therapy increases the neural activity associated with attention and motor control in the brain, activates mirror neurons in the hemisphere of the brain that controls the movement of the affected limb, and promotes motor learning [17, 18].

Research further demonstrates that GMI facilitates relaxation in the affected limb to generate endogenous substances associated with pain relief (such as

endorphins and enkephalins), increases blood circulation to the muscles required for rehabilitation exercises, and relieves pain in the affected limb by blocking the propagation of pain stimuli [19, 20]. GMI promotes the reorganization of the brain cortex related to exercise-related pain by activating the relevant neural motor networks, separating movement from pain, reducing the sense of frustration caused by rehabilitation exercises, avoiding excessive pain reactions, and thus relieving movement-evoked pain [21]. Moreover, GMI can reduce pain-related anxiety and helplessness, a key factor in reducing the level of fear of movement and increasing self-efficacy in exercise [22]. GMI sequentially activates the cortical pre-motor and motor networks, thereby diminishing the interference of pain and negative cognition on activities [20]. In this sense, GMI can be an intervention that encourages patients to imagine movements in affected limbs, exercise non-affected limbs, and reduce “avoidance” behavior.

Therefore, we hypothesized that the administration of GMI could reduce fear of movement, improve pain-related patient-reported outcomes (PROs), and increase rehabilitation exercise participation and peak expiratory flow (PEF) in patients with kinesiophobia after VATS for lung cancer. The present study aimed to explore the efficacy of GMI in patients with kinesiophobia following VATS for lung cancer.

METHODS

Study design and setting

A randomized controlled trial (RCT) was conducted using a parallel design with two groups: (i) a control group (receiving usual care) and (ii) a GMI group (receiving usual care plus GMI intervention). The study was conducted from July 2022 to December 2022 at the Department of Thoracic Surgery, in a university-affiliated tertiary hospital in Guangzhou, China.

Participant selection

Inclusion criteria for participants were: (i) aged 18 years or older; (ii) diagnosed with lung cancer and admitted for scheduled VATS; (iii) scoring ≥ 27 on the 11-item Tampa Scale for Kinesiophobia (TSK-11) on the first postoperative day; (iv) able to comprehend Putonghua, Cantonese, or Teochew dialects. Exclusion criteria were: (i) critical postoperative condition; (ii) current diagnosis of mental health disorders (e.g., depression or anxiety); (iii) severe auditory/visual impairments; (iv) unable to understand study procedures; (v) concurrently enrolled in another interventional study during hospitalization.

Sample size calculation

The sample size was calculated based on the level of fear of movement as the primary outcome indicator. We used this formula to calculate the sample size for comparing the means of two samples: $N1 = N2 = 2 [(\mu_\alpha + \mu_\beta) \sigma / \delta]^2$, with $\alpha = 0.05$, $\beta = 0.10$, $\mu_\alpha = 1.96$, and $\mu_\beta = 1.28$. According to the previous study [23], the overall standard deviation values were $\sigma = 5.89$ and $\delta = 5.69$. Considering a dropout rate of 20%, a total of 58 participants were needed.

Randomization, allocation concealment, and blinding

Participants were randomly assigned to the GMI group or the control group using the RV.UNIFORM(0,1) function in SPSS 26 with a random seed of 20220707. Sealed opaque envelopes maintained allocation concealment. Outcome assessment was conducted by two trained nursing team leaders who were blinded to the group allocation. The GMI intervention took place in a specific treatment room with the door closed during the process, and the assessors were informed not to enter. To prevent cross-contamination, the bed arrangements were coordinated to ensure that participants were not in the same ward at the same time, thus ensuring a high quality of the study integrity and the reliability of the conclusions.

Usual care rehabilitation

All participants were given usual care rehabilitation. As patients with kinesiophobia after VATS may fear pain during rehabilitation exercises, a rehabilitation exercise program with relatively moderate intensity was developed to reduce the level of fear of movement. Patients were instructed to perform respiratory and limb rehabilitation exercises as well as Baduanjin (eight-section brocade) postoperatively. (i) Respiratory rehabilitation exercise: 20–40 min per day, including abdominal breathing and effective cough; (ii) limb rehabilitation exercise: 20–40 min per day, including arm lift, arm abduction, and ear touching; (iii) Baduanjin, a traditional and popular Chinese qigong exercise that consisting of eight serial movements of the limbs, head and neck, and spine, to promote both mental and physical health [24]. The Baduanjin video was played regularly in the department corridor to guide the postoperative patients.

In addition, all patients received routine care, including maintaining the sterility, patency, and placement of the closed chest drainage system. All participants were instructed to use nonpharmacological methods for pain relief, like relaxation. If needed,

patients could receive one or more analgesics of paracetamol (acetaminophen), flurbiprofen ester (a nonsteroidal anti-inflammatory drug), or tramadol (an opioid).

GMI intervention

The GMI intervention was developed based on the GMI manual written by Moseley et al. [25], taking into account the rehabilitation exercise needs and postoperative pain characteristics of lung cancer patients. During our pilot study, the participants were able to self-manage GMI after they had practiced GMI for only 2 days. Usually, the patients in our hospital are discharged as early as the third day after VATS. Therefore, patients were required to receive at least 2 days of GMI practice. Those who practiced for less than 2 days were considered to have withdrawn from the study.

The GMI intervention was conducted in a treatment room from 16:00 to 18:00 every afternoon (the period with less routine care and treatment). It started once a day for about 40 min from the first postoperative day and was conducted for at least 2 days. If a participant needed to rest, the GMI intervention would be paused and resumed later on the same day. Three stages of GMI were performed in order: left/right discrimination, motor imagery, and mirror therapy. When participants discriminated the right limb from the left one, imagined movement, and moved the unaffected limb, no exercise or movement was done by the affected limb. Before and during GMI intervention, researchers assessed the patients' levels of pain and comfort, and administered pain medications as indicated. Accurate placement of the chest tube and proper functioning and maintenance of the chest tube drainage system were confirmed. In addition, if participants experienced shortness of breath, intensified pain, dizziness, palpitations, etc., researchers stopped GMI intervention immediately. In the GMI group, tailored emotional support, pain management strategies, and comprehensive disease-related information were provided. In addition, to ensure the effectiveness of GMI, family members of the participants were encouraged to get involved.

Stage 1: Left/right discrimination. The function of the upper limb on the surgical side is affected in patients after VATS. This stage trained laterality, the ability to identify the left or right images of the affected upper limb. At this stage, participants were required to discriminate between the right and the left sides while 21 single-upper-limb images were presented one by one on an iPad screen. Only after an answer was given, the display of the next image continued. One researcher was responsible for the presentation of images and recording accuracy, while the other was responsible for time recording. This stage lasted for around 2 min.

Stage 2: Motor imagery. This stage was to enable participants to imagine active movements without moving actually. While the participants were sitting comfortably in a chair, they watched videos of exercises for postoperative respiratory and upper limb function and listened to light music played through a Bluetooth speaker to help them relax. To minimize environmental interference, lights in the treatment room were adjusted according to participants' preferences. After watching the videos, participants were instructed to imagine respiratory and upper limb exercises themselves. The instructions went as follows: "Imagine inhaling deeply, your lower abdomen slightly bulges. Imagine exhaling slowly, your lower abdomen gradually retracts. Your body is getting lighter and lighter, as if you were transformed into a white cloud and melted into the blue sky." Our research team recorded the audio instructions in Putonghua, Cantonese, and Teochew dialects for participants to ensure their understanding. One researcher was responsible for explaining and demonstrating the process, while the other was responsible for supervision to ensure that patients could engage in motor imagery. This stage lasted for about 15–20 min.

Stage 3: Mirror therapy. This stage created illusions that participants' upper limbs were moving pain-free. A mirror with dimensions of 170 cm × 80 cm was placed in front of the participants whose non-affected upper limbs were placed on the mirror image side while the affected upper limbs were on the opposite side. One researcher demonstrated the movements until participants fully understood, while the other was responsible for supervising, guiding, and safety ensuring. Next, researchers demonstrated the movements until participants fully understood. (i) For respiratory movements, participants were guided to breathe and cough, and imagine that the affected side was performing the same movement without a closed chest drainage tube. This segment lasted for approximately 5 min. (ii) For limb movements, participants were asked to perform the movements with their unaffected upper limbs while watching the movements in the mirror to create illusions that the affected upper limbs were moving likewise. The limb movement mirror therapy was divided into three parts: arm elevation, arm abduction, and touching the contralateral ear (Figure 1). Each movement was controlled at a speed of 10–15 s, and each movement was repeated 10–20 times. After the mirror therapy was completed, participants were guided to experience the sensation of respiratory and limb movements on the surgical side. Participants were instructed to perform this stage for approximately 15–20 min.

Outcome measurements

The primary outcome was the level of fear of movement at discharge. Secondary outcomes were pain-related



FIGURE 1 Diagram of mirror therapy.

PROs, rehabilitation exercise participation, and PEF at discharge.

The level of fear of movement was assessed using the TSK-11, which consists of 11 items, each on a 4-point Likert scale with judgments ranging from strongly disagree to strongly agree [26]. The total score ranges from 11 to 44, with higher scores reflecting greater fear of movement. A score of 27 or more indicates kinesiophobia. The Cronbach's coefficient for the Chinese version was 0.883 in a sample of patients with total knee arthroplasty [27].

Pain-related PROs were assessed by the International Pain Outcomes Questionnaire (IPO-Q) [28] which consists of 13 items evaluating four domains: (i) intensity of pain (worst pain, least pain, and time spent in severe pain); (ii) interference of pain with activities (activities in and out of bed, breathing deeply or coughing, and sleep) and with emotional wellbeing (anxiety and helplessness); (iii) adverse effects (nausea, drowsiness, itch, and dizziness); (iv) perception of postoperative pain management, including pain relief from treatment, desire for more pain treatment, receipt of information about pain treatment options, participation in decisions about pain treatment, and satisfaction with pain treatment. Most items were scored using an 11-point numeric rating scale (0–10); 2 items, “time spent in severe pain” and “pain relief from treatment”, were scored using 0%–100%. Questions regarding “desire for more treatment” and “receipt of information” required dichotomous yes/no replies. Patients were also asked whether they used or received nonpharmacological interventions for pain and about the existence and severity of a persistent painful condition lasting for 3 months before surgery. Participants marked all their assessments with regard to their pain since the surgery to differentiate the acute pain caused by VATS from pre-existing chronic pain.

Rehabilitation exercise participation was measured by the Pittsburgh Rehabilitation Participation Scale (PRPS) which measures rehabilitation exercise participation ranging from 1 to 6 [29]. A higher score indicates a higher level of rehabilitation exercise participation.

The PEF was measured using the Intelligent Handheld Lung Function Instrument (Breathing Home), which can be used as an objective indicator of cough ability in patients after lung cancer resection [30]. The normal values of PEF range from 400 to 500 L/min. Preoperative PEF can predict the incidence of postoperative pulmonary complications in lung cancer patients. Patients with preoperative PEF below 250 L/min in females and 320 L/min in males are prone to a higher incidence of postoperative pulmonary complications [31]. The PEF values displayed on the instrument were recorded when the participants were being tested by the device.

Study procedures

The level of fear of movement and pain-related PROs were measured on the first postoperative day before the GMI intervention (for the GMI group), designated as T0, and at discharge, designated as T1. Rehabilitation exercise participation and PEF were recorded at T1. When the level of fear of movement and pain-related PROs were evaluated, unified instructions to the participants were used to explain. For patients who were unable to fill out the scales or questionnaires on their own, the researchers assisted them in completing their tasks.

Data analysis

SPSS 26.0 software (IBM Corp.) was used for all analyses with a statistical significance of $p < 0.05$ (two-tailed).

Exploratory data analysis and Shapiro-Wilk tests were performed to determine the normality of the data distribution. For description, means and SDs were used for normally distributed data, and medians and ranges or interquartile ranges were used for data that were not normally distributed. For comparisons between groups, the χ^2 test, independent-sample *t*-test, and Mann-Whitney *U* test were used. To determine differences between the groups over time, the TSK-11 scores before and after GMI practice were compared using paired sample *t*-tests. Analyses were conducted according to the protocol, and data from the participants who withdrew from the study were removed from the data analysis.

RESULTS

Baseline demographic and clinical characteristics

Of the 162 patients who consented to participate in this study, 58 cases suffered from kinesiophobia, yielding an incidence of kinesiophobia of 37.04%. These 58 participants who met the inclusion and exclusion criteria were randomized to usual care or usual care plus GMI group. Among the

29 participants in the GMI group, two of them withdrew due to postoperative pain and fatigue (see Figure 2, flowchart of the GMI study).

All the 27 participants in the GMI group practiced GMI once daily for two postoperative days, with two of them continuing to practice GMI for a total of 3 days. The ages of the participants ranged from 22 to 84 years. There were no statistically significant differences in the demographic and clinical characteristics between the two groups (Table 1). At discharge from the hospital, researchers recorded the use of analgesics from the electronic medical record system. All participants received an intercostal nerve block during surgery and used a patient-controlled analgesia pump after surgery. If needed, participants were given additional analgesics (Table 2).

Level of fear of movement

There was no significant difference in the score of TSK-11 on the first postoperative day between the GMI and control groups. At discharge from the hospital, the TSK-11 score in the GMI group was significantly lower than the cut-off score of kinesiophobia (Figure 3) and that in the control group ($p < 0.05$) (Table 3).

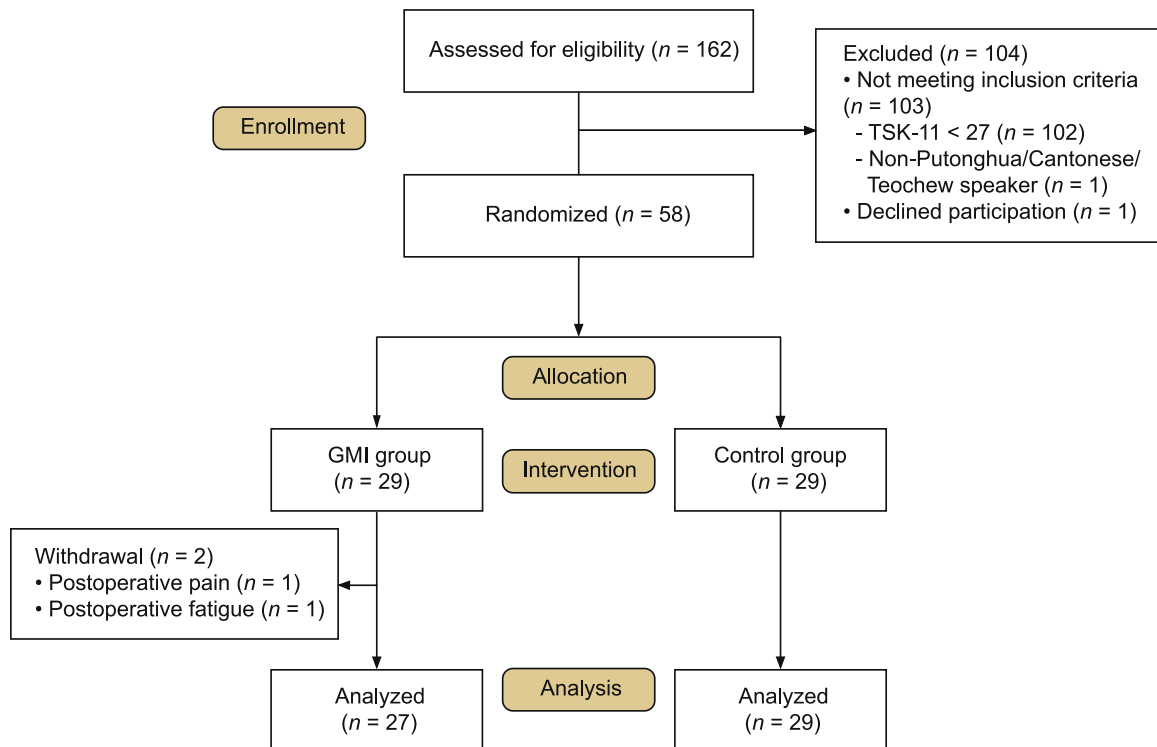


FIGURE 2 Flowchart of the GMI study. GMI, graded motor imagery; TSK-11, 11-item Tampa Scale for Kinesiophobia.

TABLE 1 Comparison of demographic and clinical characteristics between the two groups.

Variables	GMI group (n = 27)	Control group (n = 29)	t/ χ^2	p value
Gender				
Male	10 (37.04)	12 (41.38)	0.111 ^a	0.740
Female	17 (62.96)	17 (58.62)		
Age, years	58.69 ± 10.82	54.66 ± 14.92	1.179 ^b	0.244
BMI, kg/m ²	23.87 ± 3.35	23.40 ± 3.48	0.515 ^b	0.609
Marital status				
Married	26 (96.30)	26 (89.66)	0.930 ^a	0.335
Single	1 (3.70)	3 (10.34)		
Education level				
Primary school or below	8 (29.63)	6 (20.69)	0.966 ^a	0.810
Junior high school	9 (33.33)	9 (31.03)		
High school	3 (11.11)	5 (17.24)		
College or above	7 (25.93)	9 (31.03)		
Surgical site				
Left upper lung	5 (18.52)	6 (20.69)	1.294 ^a	0.936
Left lower lung	4 (14.81)	3 (10.34)		
Right upper lung	9 (33.33)	10 (34.48)		
Right middle lung	1 (3.70)	3 (10.34)		
Right lower lung	7 (25.93)	6 (20.69)		
Compound	1 (3.70)	1 (3.45)		
Surgical procedure				
Wedge resection	5 (18.52)	4 (13.79)	0.604 ^a	0.895
Segment resection	4 (14.81)	3 (10.34)		
Lobectomy	17 (62.96)	21 (72.41)		
Compound	1 (3.70)	1 (3.45)		
Lymph node dissection				
Yes	16 (59.26)	22 (75.86)	1.767 ^a	0.184
No	11 (40.74)	7 (24.14)		
Number of chest tubes				
1	18 (66.67)	12 (41.38)	3.595 ^a	0.058
2	9 (33.33)	17 (58.62)		
Duration of chest tube drainage, days	3.04 (1.74)	3.72 (1.58)	0.113 ^a	0.127
Pre-existing chronic pain	6 (22.22)	2 (6.90)	2.682 ^a	0.101

Note: Data are n (%) or mean ± SD.

Abbreviations: BMI, body mass index; GMI, graded motor imagery.

^aPearson's Chi-square test;

^bIndependent sample t-test.

Pain-related PROs

There was no statistically significant difference in pain-related PROs on the first postoperative day between

the GMI and control groups. At discharge, the GMI group scored statistically significantly lower in the intensity of pain and the interference of pain with activities and emotions than the control group. The

TABLE 2 Comparison of the number of users and dosage of additional analgesics between the two groups.

Analgesics	GMI group (n = 27)	Control group (n = 29)	Z/ χ^2	p value
Paracetamol				
Number of users	2 (7.41)	2 (6.90)	< 0.001 ^a	> 0.999
Dosage, mg	0 (0, 0)	0 (0, 0)	-0.035 ^b	0.972
Flurbiprofen ester				
Number of users	1 (3.70)	1 (3.45)	< 0.001 ^a	> 0.999
Dosage, mg	0 (0, 0)	0 (0, 0)	< 0.001 ^b	> 0.999
Tramadol				
Number of users	14 (51.85)	17 (58.62)	0.259 ^a	0.611
Dosage, mg	100 (0, 200)	200 (0, 475)	-1.573 ^b	0.116

Note: Data are n (%) or median (P_{25} , P_{75}).

Abbreviation: GMI, graded motor imagery.

^aPearson's Chi-square test;

^bMann-Whitney U test.

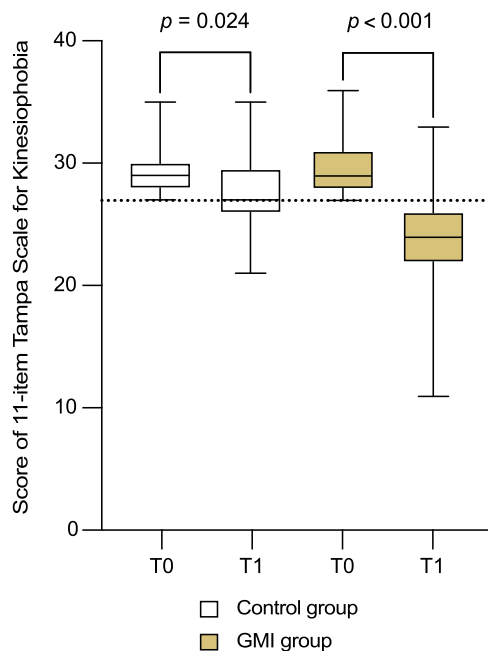


FIGURE 3 Comparison of 11-item Tampa Scale for Kinesiophobia (TSK-11) scores between the GMI and control groups on the first postoperative day (T0) and at discharge (T1). Significant within-group changes over time were observed in each group using paired sample *t*-tests. The dashed line indicates the cut-off score for kinesiophobia (≥ 27). GMI, graded motor imagery.

perception of care in the GMI group was also significantly better than that in the control group (Table 4).

Rehabilitation exercise participation

The postoperative PRPS score in the GMI group (5, interquartile range 4–5) was statistically significantly

TABLE 3 Comparison of the scores of TSK-11 between the two groups.

Time	GMI group (n = 27)	Control group (n = 29)	Z/t	p value
T0	29 (28, 31)	29 (28, 30)	-0.639 ^a	0.523
T1	23.67 \pm 4.69	27.66 \pm 3.76	3.522 ^b	0.001
Z	-5.142 ^a	-2.680 ^a		
p value	< 0.001	0.007		

Note: Data are median (P_{25} , P_{75}) or mean \pm SD.

Abbreviations: GMI, graded motor imagery; TSK-11, 11-item Tampa Scale for Kinesiophobia; T0, on the first postoperative day; T1, at discharge.

^aMann-Whitney U test.

^bIndependent sample *t*-test.

higher than that in the control group (3, interquartile range 3–3, $Z = -4.430$, $p < 0.001$).

PEF

Preoperative PEF values in the GMI and control groups were 372.18 (SD = 100.84) L/min and 408.27 (SD = 95.93) L/min, respectively, showing no significant difference ($t = -1.360$, $p = 0.180$). At discharge, PEF was 247.46 (SD = 84.09) L/min in the GMI group, significantly higher than that in the control group [187.76 (SD = 84.64) L/min] ($t = -2.527$, $p = 0.015$).

Length of postoperative hospital stay

The length of postoperative hospital stay was 5.19 (SD = 2.19) days in the GMI group, statistically

TABLE 4 Comparison of the pain-related PROs between the two groups.

Variables	Group	GMI group (n = 27)	Control group (n = 29)	Z/ χ^2	p value
Intensity of pain					
Worst pain, score	T0	7 (5, 8)	7 (6.5, 8)	-1.460 ^a	0.144
	T1	5 (3, 7)	6 (5, 8)	-2.716 ^a	0.007
Least pain, score	T0	1 (1, 2.5)	2 (1, 2)	-0.101 ^a	0.919
	T1	0 (0, 2)	1 (1, 2.5)	-2.269 ^a	0.023
Time spent in severe pain, %	T0	20 (10, 20)	10 (10, 20)	-0.784 ^a	0.433
	T1	30 (20, 40)	20 (15, 40)	-0.318 ^a	0.751
Interference of pain with activities					
Activities in bed, score	T0	5 (3, 5)	5 (4, 6)	-1.119 ^a	0.263
	T1	3 (2, 4)	4 (3, 5)	-3.665 ^a	< 0.001
Breathing or coughing, score	T0	6 (4, 7)	6 (5, 7)	-0.223 ^a	0.824
	T1	4 (3, 5)	5 (4, 7)	-3.921 ^a	< 0.001
Activities out of bed, score	T0	5 (4, 6)	5 (5, 6)	-0.582 ^a	0.561
	T1	2 (2, 3)	3 (2, 5)	-2.207 ^a	0.027
Sleep, score	T0	2 (1, 4)	2 (2, 3)	-0.490 ^a	0.624
	T1	1 (0, 3)	2 (1.5, 5)	-2.815 ^a	0.005
Emotional impairment					
Anxiety, score	T0	1 (0, 2.5)	0 (0, 2)	-1.796 ^a	0.072
	T1	0 (0, 2)	2 (0, 4)	-2.142 ^a	0.032
Helplessness, score	T0	0 (0, 2)	0 (0, 1)	-1.192 ^a	0.233
	T1	0 (0, 1)	1 (0, 3)	-2.657 ^a	0.008
Side effects					
Nausea, score	T0	0 (0, 0)	0 (0, 0)	-0.495 ^a	0.620
	T1	0 (0, 0)	0 (0, 0)	-1.327 ^a	0.185
Dizziness, score	T0	1 (0, 2)	0 (0, 1)	-1.795 ^a	0.073
	T1	0 (0, 0)	0 (0, 1.5)	-0.605 ^a	0.545
Perception of care					
Pain relief from treatment, %	T0	60 (50, 65)	60 (50, 60)	-0.048 ^a	0.962
	T1	80 (70, 90)	60 (55, 70)	-4.856 ^a	< 0.001
Desire for more pain treatment	T0	16 (59.26)	23 (79.31)	2.659 ^b	0.103
	T1	9 (33.33)	13 (44.83)	0.982 ^b	0.322
Receipt of information about pain treatment options	T0	8 (29.63)	4 (13.79)	2.083 ^b	0.149
	T1	24 (88.89)	15 (51.72)	8.311 ^b	0.004
Participation in decisions about pain treatment, score	T0	7 (6, 8)	6 (5, 8)	-1.100 ^a	0.271
	T1	8 (8, 9)	6 (5, 6.5)	-5.249 ^a	< 0.001
Satisfaction with pain treatment, score	T0	7 (6, 8)	7 (6, 8)	-0.192 ^a	0.847
	T1	8 (8, 9)	6 (5.5, 8)	-4.912 ^a	< 0.001

Note: Data are n (%) or median (P_{25} , P_{75}).

Abbreviations: GMI, graded motor imagery; PROs, patient-reported outcomes; T0, on the first postoperative day; T1, at discharge.

^aMann-Whitney *U* test;

^bPearson's Chi-square test. The side effects of drowsiness and itching in all participants were 0.

significantly lower than that in the control group (6.71 days, SD = 2.98, $t = -2.164$, $p = 0.035$).

DISCUSSION

Our present RCT demonstrated that GMI intervention reduced the level of fear of movement, increased pain-related PROs, and improved postoperative rehabilitation exercise participation and PEF in patients with kinesiophobia after VATS. GMI intervention also reduced surgery-to-discharge interval. The patients in the intervention group were discharged almost 1 day earlier than those in the control group. Focusing on the needs of patients after VATS, we developed the GMI intervention in addition to usual care, which encompassed respiratory and upper limb exercises, and incorporated it into the second stage of motor imagery and the third stage of mirror therapy. Our findings showed that participants who received GMI treatment had greater improvements in all outcome measurements than those treated with only usual care, indicating that our rehabilitation program is suitable for lung cancer patients undergoing VATS.

The early period of hospitalization is a critical period to alleviate the level of postoperative fear of movement [32]. This study showed that GMI reduced the fear and uncertainty towards rehabilitation exercises in patients with postoperative kinesiophobia following VATS as compared to the usual care. A similar result has been found in other patient populations experiencing extremity pain [33]. In a study of 107 patients with chronic shoulder pain syndrome, neuroimaging revealed that after implementing GMI intervention, there was a decrease in the activity of the sensory cortex and interstitial circuits, which helped to desensitize the hyperalert nervous system [19]. Moreover, during our GMI intervention, relaxing music and participatory discourse in the patients' preferred dialect might increase their satisfaction with pain treatment.

GMI provides participants with more ways to cope with pain. The GMI group demonstrated a better perception of pain management compared to the control group. This is evidenced by a higher percentage of pain relief, more comprehensive information on pain treatment, greater involvement in pain management, and increased satisfaction with the pain treatment received. Likewise, other studies showed that GMI could reduce pain at rest and movement-evoked pain in the acute period after distal radius fracture, post-traumatic stiffness of the elbow, and total knee arthroplasty [10–12]. GMI is a continuous and gradual process of motor imagination. A systematic review indicates that combining motor imagery with routine care could reduce pain intensity [34]. Patients' perception of acute postoperative pain treatment is

influenced by multiple factors. Patients' decisions on participating in postoperative pain treatment was associated with several better outcomes regarding the pain experience and their perception of pain management, such as less time spent in severe pain, less anxiety, less interference with sleep, more pain relief, and higher satisfaction [35]. In our study, participants in the GMI group were more involved in pain treatment, also resulting in better pain related outcomes. The control group consumed twice the amount of tramadol compared to the GMI group yet reported higher pain levels, indicating that the GMI intervention may have effectively contributed to pain relief.

The PRPS results indicated that most participants in the GMI group took part in and finished all exercises with maximal effort. GMI provided guidance and encouraged family participation, which was a positive factor in increasing rehabilitation exercise participation. Besides, as participants in the GMI group received personalized emotional support, pain treatment, and disease-related information, their rehabilitation exercise participation was further increased.

PEF can be used as a quantitative indicator of coughing ability in patients after lung cancer resection [36], indicating that GMI intervention could improve PEF in patients after VATS. In our study, the GMI group had a higher PEF than the control group at the time of discharge. Effective coughing, crucial for expelling phlegm and blood clots from the lungs to avert postoperative complications, is predominantly hindered by pain [37]. Consequently, it is vital to encourage participants to intensify respiratory exercises. Studies reported that GMI intervention facilitates this and enhances PEF by prompting participants to relax their respiratory muscles and engage intercostal and abdominal respiratory muscles, and by instructing participants with diaphragmatic and pursed-lip breathing techniques [34, 37].

The durations for GMI intervention vary in different populations of patients because the rehabilitation time required for specific surgical patients varies. The GMI intervention duration in our study was only 2 days because the whole hospitalization period required was very limited. Dilek et al. conducted an 8-week GMI intervention for patients with distal radius fractures [10]. Birinci et al. conducted GMI intervention twice a week for 6 weeks in patients with posttraumatic stiffness of the elbow [11]. Candiri et al. administered GMI intervention three times a week for 6 weeks in patients after total knee arthroplasty [12]. However, compared with other similar studies, our short-term intervention achieved the effects expected, suggesting that our GMI intervention program may help thoracic surgery professionals improve patient outcomes during the postoperative hospitalization period in patients with postoperative kinesiophobia.

STRENGTHS AND LIMITATIONS

Our GMI intervention was carried out in combination with specific routine rehabilitation exercises, which were customized to patients with kinesiophobia after VATS. As most of the participants received the GMI intervention for only 2 days, the results could not fully illustrate the effects of GMI on postoperative kinesiophobia, pain, and rehabilitation. Therefore, future multicenter studies with a larger sample, longer duration, increased follow-up time, and more outcome measurements are needed to track the effectiveness of the GMI intervention.

FUTURE DIRECTIONS FOR RESEARCH AND PRACTICE

Qualitative research could be conducted to explore the experience of patients practicing GMI, and more personalized programs could be developed to encourage patients with kinesiophobia to practice GMI after VATS. It is suggested that GMI could be integrated into routine rehabilitation care in clinical settings to help improve postoperative outcomes of lung cancer patients with kinesiophobia.

CONCLUSION

GMI can reduce fear of movement, improve pain-related PROs, and increase rehabilitation exercise participation and PEF in lung cancer patients with kinesiophobia after VATS.

AUTHOR CONTRIBUTIONS

Xinyuan Zhang and Xiaohong Zhang contributed to the conception and design of the study, data collection and analysis, and funding acquisition. Xingu Chen, Shuping Liang, and Yan Yu contributed to data collection. Hui Li and Qunqing Chen provided resources for the study. Li Li contributed to the conception and design of the study, data interpretation, and funding acquisition. All authors wrote and revised the manuscript and approved the final version. All authors are accountable for all aspects of the work.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical approval of the study was obtained from the Medical Ethical Committee of Zhujiang Hospital, Southern Medical University (approval number: 2022-KY-047-02). The study conformed to the standards set by the Declaration of Helsinki and Good Clinical Practice guidelines and was registered at the Chinese Clinical Trial Registry (ChiCTR2300072612). Written informed consent was obtained from each participant.

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