Effectiveness of motor imagery techniques in the treatment of chronic musculoskeletal pain: A scoping review

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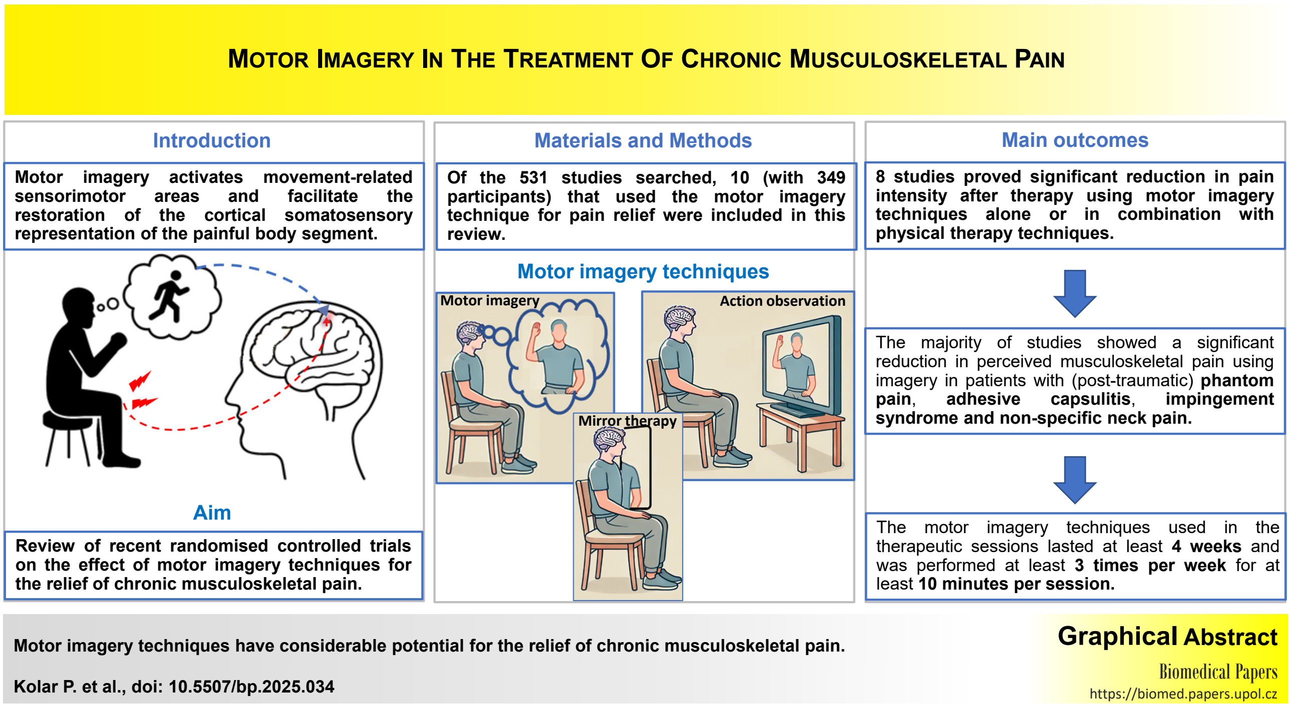
Recent neurophysiological studies provide evidence that motor imagery techniques, as a non-pharmacological intervention, reduce the perception of pain intensity at the cortical level and can therefore be used in clinical practice in patients with chronic musculoskeletal pain (CMP). The aim of this scoping review was to evaluate recent randomised controlled trials on the effect of motor imagery techniques for the relief of CMP.

Four databases (PubMed, Scopus, Proquest, Cochrane Clinical Trials) were searched to identify randomised controlled trials on the effect of motor imagery techniques on the subjective intensity of musculoskeletal pain lasting for > 3 months in adults. Ten trials (349 participants) were identified for inclusion in this scoping review conducted following the PRISMA-ScR guidelines.

The majority of the included studies showed that the motor imagery techniques reduced pain intensity in patients with CMP (namely in patients with post-traumatic phantom limb pain, adhesive capsulitis, impingement syndrome and non-specific neck pain). immediately after therapeutic sessions, compared with control groups, and also in follow-up measurements up to a few months after baseline measurement. The motor imagery techniques used in the therapeutic sessions lasted more than four weeks, with at least three sessions of at least ten minutes each performed per week.

The main limitations were the lack of high-quality, double-blind evidence with sufficient numbers of participants.

This review summarises randomised controlled trials and shows that motor imagery techniques have considerable potential for the relief of CMP. High-quality evidence is needed to further support the use of motor imagery in clinical practice.



Key words: chronic pain, musculoskeletal, motor imagery, mirror therapy

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INTRODUCTION

Pain is defined as a complex unpleasant multifactorial subjective experience. Chronic pain is defined as pain lasting more than three months[1] and, unlike acute pain, does not have any protective or regenerative character[2]. Chronic pain limits patients both physically and socially, often leading to a significant reduction in quality of life[3]. Musculoskeletal pain affects bones, muscles, ligaments, and tendons, and is associated with musculoskeletal disorders[4]. Its management usually requires a multidisciplinary approach. Non-pharmacological treatment options including motor imagery techniques are currently accepted as the preferred treatment for patients with chronic pain[5]. According to current neuroscientific understanding, motor imagery techniques appear to act to a great extent at the level of sensorimotor cortical areas, which are maladaptively remodelled in relation to chronic pain perception[6].

Chronic musculoskeletal pain results in a complex set of changes in nociceptive pathways at different levels of the central nervous system[7]. These changes may cause pain to persist long after the original nociceptive input has ended[8]. This can occur even without ongoing anatomical or structural damage to musculoskeletal tissues[9]. As nociceptive processing involves a large brain network, the perception of chronic pain may be based on a maladaptive reorganisation of these brain structures. A relationship has also been shown between the duration of pain and the extent of cortical changes – simply put, the longer the pain lasts, the greater the cortical reorganization is[10].

Maladaptive reorganisation mainly affects the primary somatosensory cortex (S1), which plays an important role in pain perception[7,11-14]. S1 processes nociceptive information and also somatosensory (proprioceptive and tactile) information about the position and movement of body segments. Brodmann's area 3b processes sharp and well-localised pain, whereas Brodmann's area 3a is expected to process deep, difficult-to-locate pain signals and it has also been defined as a key region for the processing of proprioceptive perceptions[14]. Thus, an unwanted interference of nociceptive and proprioceptive information may occur, in this area – the information about the position or movement of the painful segment is masked by the nociceptive sensation[14,15]. Continuous painful stimuli reduce the ability to process non-nociceptive somatosensory afferent information, which results in nociception-induced sensory deprivation and reduced cortical representation of the affected area[16,17] as has been demonstrated in patients with phantom pain[11], with complex regional pain syndrome[12], and neuropathic pain[13]. Generally neuropathic pain, caused by a lesion or disease of the somatosensory nervous system, whether observed in clinical populations or induced experimentally, is associated with functional and structural reorganization of the somatosensory cortex[13].

During motor imagery the brain creates a so-called internal kinesthetic model of the movement without actually performing the movement[18,19]. The areas of the brain that are active during motor imagery largely overlap with those that are active when performing the real movement. Motor imagery or action observation activates cortical areas such as the premotor cortex, supplementary motor area, S1, and inferior parietal cortex[20-26].

The potential of imagery techniques in the treatment of chronic pain is based on the activation of movement-related sensorimotor areas that further facilitate the restoration of the cortical somatosensory representation of the segment that the patient perceives as painful[18,27,28]. Motor imagery techniques based on an internal kinesthetic model used in the management of chronic pain include the following:

- **Motor Imagery (MI) –** the patient only imagines a specific movement. It is actually based on the hypothesised internal kinesthetic model, which is stored in the working memory and makes it possible to predict the future sensorimotor course of the movement during its planning and execution[18].
- **Action observation (AO) –** the patient observes another person movement in real time and space, or in the video or in virtual reality. During action observation, a massive activation of mirror neurons occurs. The neurophysiological basis is similar to motor imagery – the internal kinesthetic model[18].
- **Mirror therapy (MT) –** the patient observes the movement of their healthy limb in a mirror positioned in the midline of the body so that the reflection of the moving limb creates an illusory perception of the movement of the pathological limb hidden behind the mirror[29,30]. During MT the internal kinesthetic model is enhanced by visual feedback and somatosensory afference from the moving limb behind the mirror[12].
- **Graded Motor Imagery (GMI) –** a therapeutic approach that combines the two imagery techniques described above. It consists of three well-defined phases (laterality training, motor imagery, mirror therapy) that are graded from simpler to more complex in terms of the expected progressive activation of sensorimotor areas during each phase[27,28]. This progressive activation of the sensorimotor cortices helps to avoid the unpleasant pain sensations with mirror therapy alone[29].

The aim of this paper was to review available randomized controlled trials (RCTs), for the relief of chronic musculoskeletal pain, to compare and synthesise their results regarding the effectiveness of interventions for pain reduction. This review focuses only on studies that are no more than 10 years old and that deal with motor imagery techniques (such as motor imagery, action observation, mirror therapy and graded motor imagery).

MATERIALS AND METHODS

Search strategy and selection criteria

The following keywords were defined for the development of the review: chronic pain, musculoskeletal pain, motor imagery, mirror therapy, imagery techniques. Various combinations of the following search equation were used: ("chronic pain" AND "musculoskeletal") AND ("motor imagery" OR "mirror therapy" OR "imagery techniques"). Relevant articles were searched by two independent reviewers (MK, MH) using these keywords in the PubMed, Proquest, Scopus and Cochrane Clinical Trials databases. These two reviewers assessed independently whether each study met the inclusion criteria based on full-text evaluation. In cases of disagreement, a third reviewer (BK) was consulted to resolve the conflict. All data were extracted manually into an electronic form. No preliminary pilot testing of the data extraction procedure was carried out prior to the review. The search was conducted between November 2022 and January 2024. A systematic review protocol was not registered. This scoping review was conducted following the PRISMA-ScR checklist to ensure transparent and systematic reporting.

Criteria for inclusion in the review as follows: (1) The article must be a randomised controlled trial published in English between 2013 and 2023. (2) The population studied had to be adults (over 18 years of age) with chronic musculoskeletal pain (defined as pain that initially resulted from a functional or structural insult to musculoskeletal structures – bones, muscles, ligaments and tendons – and lasted more than three months). The inclusion criteria did not set a lower limit for the number of study participants. (3) The intervention used in the trials must be described as a motor imagery technique (specifically motor imagery, action observation, mirror therapy and graded motor imagery) and must be used as an intervention to reduce subjectively perceived pain intensity. The duration of the therapy must be realized at least in two days, so it is not a single session. (4) The measurement of pain level must be the primary outcome of the study and must be assessed using a numerical scale. Only trials that reported numerical data were included. Trials were excluded if they did not meet the inclusion criteria. Criteria for the type of therapy in the control group were specified.

Risk of bias assessment

Risk of bias for each included randomized controlled trial was assessed using Cochrane's revised tool for assessing risk of bias in randomized trials (RoB 2). This tool evaluates five domains. Each domain was judged as "low risk", "some concerns" or "high risk", and an overall risk of bias judgment was assigned according to the RoB 2 guidance.

RESULTS

The process of selecting studies for inclusion in the review

A total of 531 studies were identified using the keywords. After removing duplicates, 221 studies were excluded based on title and abstract. These were mainly review articles or basic research studies investigating the mechanism of the analgesic effect of imagery on neural activity. The full texts of 30 studies were screened, of which 10 studies met the inclusion criteria. A flow chart of the screening process is shown in Fig. 1.

Specification of studies included in the development of the review

The trials[31-40] included in the review are detailed in Table 1.

MT was used in three trials[31-33], two trials[34,35] investigated the effect of MI in combination with conventional therapy or with AO. Two trials investigated the GMI concept[36,37], one trial used MT in combination with tactile therapy[38], one used MI in combination with AO and neck exercise[39] and one trial used AO in combination with conventional therapy as an intervention[40].

The most commonly used techniques in the control group were "conventional therapy" and "placebo mirror therapy" (see Table 1). "Conventional therapy" represents classical physiotherapy techniques on a neurophysiological basis or manual therapy including stretching[37], and "placebo mirror therapy" means that the mirror is covered during therapy.

A total of 349 participants were included in the trials, with 167 participants in the experimental groups and 177 participants in the control groups.

Results of the studies

According to the review results, 8 (ref.[31-37,39]) of the 10 studies showed a significant reduction in pain intensity after therapy using motor imagery techniques, see Table 2.

Regarding the type of motor imagery technique, significant improvement was also found in 3 out of 4 MT trials[31-33], 2 GMI trials[36,37] and all 3 MI trials[34,35,39]. Significant pain relief compared with the control group was reported in 6 studies[31,32,34-37]. One study[39] reported a worsening of pain after the intervention. In two trials, there was a reduction in pain after the intervention, but this was not significant[38,40].

Imagery for chronic musculoskeletal pain showed a significant reduction in pain in the experimental group immediately after the end of therapy in 8 out of 10 trials[31-36,39]. Follow-up measurements at three[31,37] and six months[31,36] after the end of therapy showed a positive effect of the motor imagery intervention (see Table 2). When comparing the effectiveness of the treatment in the experimental and control groups, pain decreased significantly in the experimental group immediately after therapy[31-36], three months after therapy[31,37] and six months after intervention[31,36]. In two studies were found not significant changes in the experimental group in comparison to control one immediately after therapy[40] and six months post-intevention[37.]

The imagery used within the therapeutic session lasted 4–6 weeks (if specified), except one lasting 12 weeks[37], at least 3 times per week (if specified), with an intensity of 10–25 min per day, except one[37] with duration 45–60 min per day. Motor imagery as an intervention was used alone in 4 trials[31,33,36,38] or in combination with conventional physiotherapy in the remaining 6 trials[32,34,35,37,39,40]. Below are described results organized by motor imagery technique.

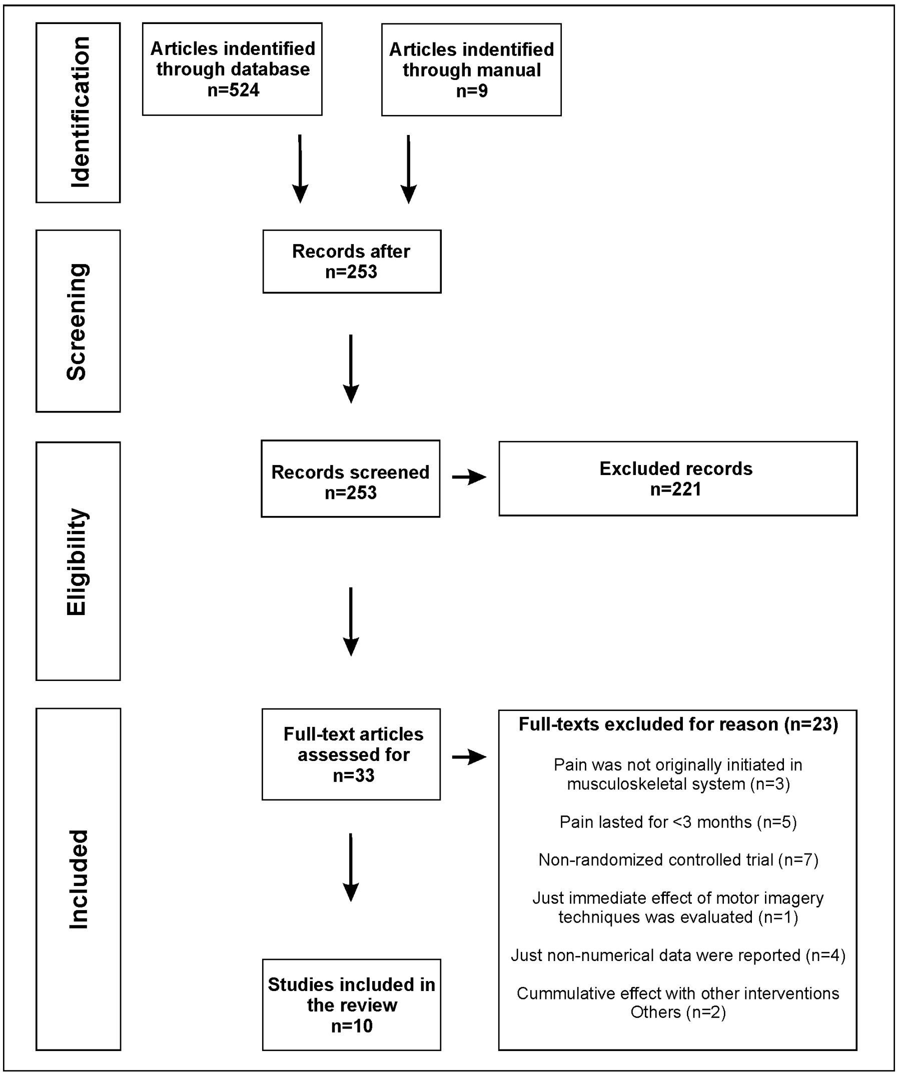

Fig. 1. Study flow chart.

Efficiency of motor imagery

MI trials[34,35] reported a significant reduction in pain from impingement syndrome and non-specific neck pain in the experimental group immediately after therapy, as well as compared to the control group. Therapy typically lasted 4–6 weeks, with three sessions per week of 10–25 min each, and included conventional therapy such as exercise.

Efficiency of action observation

Only one study[40] evaluated the effect of AO in combination with conventional exercise. No significant difference in pain relief was found before or after the intervention between the experimental and control groups. However, both groups showed a significant improvement in outcome measures after the intervention. The therapy was performed three times weekly for six weeks.

Efficiency of motor imagery in combination with action observation

In the study by Özcan et al.[39], the experimental group receiving a combination of action observation (AO) and motor imagery (MI) showed a significant reduction in non-specific neck pain after training. Both the experimental and control groups underwent conventional therapy, such as exercise. The therapy lasted for four weeks, with five sessions per week.

Efficiency of mirror therapy

Significant improvements were found for MT in three out of four trials[31-33] after therapy and in two out of four trials[31,32] compared to the control group. Two of the studies included post-traumatic phantom pain[31,33], and one included adhesive capsulitis[32]. MT was used as a single technique in two studies[31,33]. One study[38] showed non-significant improvement compared to the control group; further this study reported no significant difference compared to tactile therapy or a combination of MT and tactile therapy. In all MT studies the therapy lasted 4–6 weeks, with three 10–25 min sessions per week. In one study[31] the effect of therapy persisted even in follow ups after 3 and 6 months.

Efficiency of graded motor imagery

Both GMI trials[36,37] reported significant improvements in pain relief after GMI therapy, at three- and six-month

Table 1. Basic characteristics of the studies included in the review.

Study	Pain type and total number of participants (n), number of participants in experimental group (EG) and number of participants in control group (CG)		Mean age of participants ± SD or [median (IQR)]; sex	Type of pain therapy in experimental group using motor imagery technique	Type of pain therapy in control group	Outcome pain intensity measures	Therapy duration in weeks	Therapy intensity (duration of one therapeutic unit)	Ref.
Anaforoğlu Külünkoğlu et al. 2019	Post-traumatic phantom pain	n=40 EG=20 CG=20	 32.60 ± 7.39 years 12 females, 8 males 29.60 ± 6.87 years 13 females, 7 males	MT	Phantom exercise	VAS [0–100]	4 weeks	daily (15 min)	31
Baskaya et al. 2018	Adhesive capsulitis	n=30 EG=15 CG=15	 59.8 ± 10.6 years 12 females, 3 males 54.4 ± 7.6 years 9 females, 6 males	MT + conventional therapy	Placebo MT + conventional therapy	VAS [0–10]	NS	10 sessions (20 min)	32
Finn et al. 2017	Post traumatic phantom pain	n=15 EG=9 CG=6	<19;68> ≈ 28.3 years[£] 9 males ≈ 29.3 years[£] 6 males	MT	Placebo MT	VAS [0–100]	4 weeks	5 times per week (15 min)	33
Mena-Del Horno et al. 2023	Adhesive capsulitis	EG = 17 CG = 17	54.2 ± 7.48 years 15 females, 2 males 53.4 ± 7.87 years 9 females, 8 males	GMI + manual therapy	Manual therapy	VAS [0–100]	12 weeks	5 times per week home stretching programme (45–60 min), in EG added GMI and sensory discrimination training 1 time per week manual therapy	37
Hoyek et al. 2014	Impingement syndrome pain	n=16 EG=8 CG=8	46.31 ± 9.02 years[££] NS 4 females and 4 males NS 4 females and 4 males	MI + conventional therapy	Conventional therapy	VAS [0–10]	NS	10 sessions/3 times per week (EG: 15 min of MI + 45 min of conventional therapy, CG: 45 min of conventional therapy)	34

Table 1. *(Continued)*

Study	Pain type and total number of participants (n), number of participants in experimental group (EG) and number of participants in control group (CG)		Mean age of participants ± SD or [median (IQR)]; sex	Type of pain therapy in experimental group using motor imagery technique	Type of pain therapy in control group	Outcome pain intensity measures	Therapy duration in weeks	Therapy intensity (duration of one therapeutic unit)	Ref.
Javdaneh et al. 2021	Non-specific neck pain	n=72 EG=24 CG1=24 CG2=24	31.18 ± 6.37 years 10 females 14 males 33.45 ± 7.08 years 13 females 11 males 33.70 ± 8.13 years 12 females 12 males	MI + neck exercises	CG1: Neck exercises CG2: No intervention	VAS [0–100]	6 weeks	3 times per week (EG: 25 min of MI + 40–50 min of exercises, CG1: 40–50 min of exercises)	35
Limakatso et al. 2020	Phantom pain	n=21 EG=11 CG=10	[63 (53 to 65) years] 3 females 8 males [62 (59 to 67) years] 2 females 8 males	GMI	Conventional therapy	BPI [0–10]	6 weeks	12 sessions (10 min)	36
Ol et al. 2018	Postraumatic Phantom pain	n=45 EG1=15	55.7 years 1 female, 44 males[£££] 57.5 ± 6.0 years NS	MT (EG1)	Tactile therapy	VAS [0–10]	4 weeks	2 times per day (EG1+CG: 5 min)	38
		EG2=15 CG=15	52.0 ± 7.0 years NS 57.6 ± 5.7 years NS	MT + tactile therapy (EG2)				2 times per day (EG2: 10 min)	
Özcan et al. 2019	Non-specific neck pain	n=40 EG=20 CG=20	20.10 ± 1.33 5 males, 15 females 19.70 ± 1.17 years 2 males ,18 females	MI + AO + neck exercises	Neck exercises	VAS [0–10]	4 weeks	5 times per week (EG: 15 min of MI and AO + 45 min of exercises, CG: 45 min of exercises)	39
Öztürk et al. 2021	Gonarthrosis pain	n=36 EG=18 CG=18	61.1 ± 7.1 15 females 1 male 58.3 ± 6.0 years 14 females, 4 males	AO + conventional therapy	Conventional therapy	VAS [0–10]	6 weeks	3 times per week (EG: 15 min of AO + 45 min of conventional therapy, EG: 45 min of conventional therapy)	40

MT, mirror therapy; MI, motor imagery therapy; AO, action observation therapy; GMI, graded motor imagery; VAS, visual analogue scale; BPI, brief pain inventory; NS, not stated; SPADI, shoulder pain and disability index; [£] – the study does not report mean age per group directly, so these are calculated estimates based on the listed ages; [££] – age stated for all participants independently on the group allocation; [£££] – not stated the sex distribution for all tested groups separately.

Table 2. Results of the included studies on chronic musculoskeletal pain relief.

Grouping by the motor imagery technique	Study	Outcome measures intervals from the baseline	Specification of EG	Pain intensity decrease in experimental group using motor imagery technique *	*P*	Pain intensity decrease in experimental group in comparison to control group **	*P*	Ref.
Motor Imagery	Hoyek et al. 2014	after therapy		93.1%	**<0.001**	27.18%	**<0.001**	34
	Javdaneh et al. 2021	after therapy		76.9%	**<0.001**	EGvsCG1 = 31 EGvsCG2 = 74.5	**<0.001**	35
Action Observation	Öztürk et al. 2021	after therapy		59.6%	0.8	8.8%	NS	40
Motor Imagery and Action Observation	Özcan et al. 2018	after therapy		67.00%	**<0.001**	−9.98%	0.608	39
Mirror Therapy	Anaforoğlu Külünkoğlu et al. 2019	after therapy		89.4%	**<0.001**	22%	**<0.001**	31
		after 3 months		97.2%	**<0.001**	15.7%	**<0.001**	
		after 6 months		100%	**<0.001**	9.6%	**<0.001**	
	Baskaya et al. 2018	after therapy		91%	**0.0001**	18.1%	**0.007**	32
	Finn et al. 2017	after therapy		33.5%	**0.001**	38%	0.601	33
	Ol et al. 2018	after therapy	EG 1	65%	>0.05	8.4%	>0.05	38
			EG 2	84.7%		28.1%		
Graded Motor Imagery	Mena-Del Horno et al. 2023	after 3 months		68.40%	**<0.001**	23.70%	**<0.001**	37
		after 6 months		43.40%	**<0.001**	−25.40%	NS	
	Limakatso et al. 2020	after therapy		85%	**0.007**	31.2%	**0.02**	36
		after 3 months		100%	**<0.001**	57.8%	0.14	
		after 6 months		100%	**<0.001**	173.2%	**0.03**	

EG, experimental group; *P*, level of significance; xxx, not shown.
*percentage counted as 100*D/B, where B represents baseline outcome data and D represents difference between baseline outcome data and outcome data measured after therapy.
** percentage difference between experimental and control group outcome data.

follow-ups, and compared to the control group. The significant immediate effect observed in study[36], which involved 12 sessions over six weeks, was not found. In these two studies, therapy was carried out for 6–12 weeks, two to five times per week.

DISCUSSION

Effectiveness of motor imagery techniques in the treatment of chronic musculoskeletal pain

According to the results, the majority of trials showed a significant reduction in perceived pain using imagery techniques (Table 2). However, for a more complete comparison of studies, it would be necessary to consider the risk of bias of individual studies.

As mentioned previously, chronic pain in patients with musculoskeletal disorders has been shown to cause neuroplastic changes at the level of the sensorimotor cortex[11], resulting in impaired perception of the actual position or movement of the affected limb[27,41,42]. Interventions based on the activation of sensorimotor cortical areas are thought to normalise the functional organisation of the cortex[43]. This is where imagery techniques come in, by activating somatosensory and motor cortical areas without actually performing the movement[24,44-47].

The following section presents a discussion of the results, structured by the type of motor imagery applied.

Motor imagery

In the reviewed trials, MI was only evaluated in combination with conventional training[34,35] or AO and conventional training[39]. In all these trials, the intervention led to a reduction in pain at the end of therapy, and in two trials without AO even compared with the control group. In the MI group, of notein Hoyek et al.[34] and Özcan et al.[39] the participants were not blinded to their intervention and all therapy was provided by a single therapist. However, the nature of the intervention precluded blinding participants or therapists. In all three studies, the results show a significant reduction in pain after the intervention in the experimental group, and two studies[34,35] show the significant difference between groups. Studies using MI as an intervention involved patients with nociceptive pain, which origins from tissue damage or inflammation, such as shoulder impingement syndrome[34] or non-specific chronic neck pain[35]. From the results of the reviewed trials, MI combined with exercise is an effective form of therapy. However, the evidence is of low quality and the number of included trials, and the total number of participants is small.

Action observation

Only one study[40] in the sample evaluated the effect of AO in combination with conventional exercise, but the results suggested that AO added to an exercise programme did not provide any additional benefit for pain relief in patients with knee osteoarthrosis. The single AO study (Öztürk et al.[40]) lacked rigorous data. AO might be more effective in conditions with strong cortical reorganization (e.g., CRPS or phantom pain) than in degenerative conditions like gonarthrosis, but this hypothesis needs to be further tested.

Motor imagery and action observation

MI combined with AO and exercise significantly reduced neck pain, in Özcan et al.[39], but combining AO with MI had no advantage exercise alone.

Mirror therapy

MT is a relatively common non-pharmacological treatment for phantom limb pain representing neuropathic pain, but there is no really robust evidence for its effectiveness[47]. Of the trials reviewed, 4 dealt with MT (ref.[31-33,38]), 3 included patients with phantom limb pain[31,33,38]. One study[31] reported significant pain reduction, including sustained effects at 3–6 months. This study included a patient with adhesive capsulitis[32] and had positive results. In the MT group, however, some of the studies were biased in terms of research methodology. In study of Finn et al.[33], participants were aware of their assigned intervention and participants in the control group crossed over to the experimental group earlier than planned, which was a significant deviation from the planned intervention. In the study of Ol et al.[38], participants were not randomly assigned to the groups and baseline pain levels differed greatly between the groups. Study of Ol et al.[38] showed no effect of MT on reducing pain intensity. The results of studies of Anaforoğlu Külünkoğlu et al.[31] and Baskaya et al.[32] are similar to those of study of Finn et al.[33], there were no significant differences in pain reduction between groups. According to these results MT represent an effective intervention for pain relief, but the results should be interpreted with caution due to the risk of bias mentioned above. In addition, the number of included trials and the total number of participants is small.

Graded motor imagery

The GMI was used in two reviewed papers[36,37] with the first one concerning phantom limb pain, where the pain relief was obtained after therapy, six months after therapy and even in comparison to control group. In this study the sample size is too small to permit drawing conclusions. The other study compared a manual therapy and home stretching programme with a manual therapy programme including home stretching, sensory discrimination training and GMI in patients with adhesive capsulitis (frozen shoulder). Much greater pain relief was observed in the experimental group after the three-month treatment compared with the control group. However, after the six-month follow-up, the control group showed greater pain relief than the experimental group. Studies suggesting effectiveness of GMI in patients with complex regional pain syndrome (type 1) were realized by Moseley[27,28].

Influence of pain mechanism on motor imagery outcomes

The effectiveness of motor imagery techniques may vary depending on the underlying pain mechanism. Conditions with a neuropathic component – such as phantom limb pain – tend to show more consistent and sustained benefits, likely due to the significant cortical reorganization associated with these syndromes. In contrast, nociceptive pain conditions, such as adhesive capsulitis, impingement syndrome, or osteoarthritis, also respond positively but with less uniform outcomes. This distinction suggests that motor imagery interventions may be particularly valuable in cases where central sensitization and maladaptive neuroplasticity play a dominant role.

Adverse effect of mental imagery techniques

Adverse effects or contraindications of imaginative techniques were not reported in the trials. In the trials included in the review, the pharmacological treatment was unchanged throughout the intervention. There were no reports of concomitant therapies other than those monitored (such as psychotherapy or rehabilitation). Patient compliance is essential for practical reasons and also because of the techniques used in autotherapy.

Although the individual studies included in the review differ in the type of therapy used in the control groups, the control training always focused on painful limb movements (residual limb in amputees) or placebo therapy. It should be noted that the control therapy types were also effective in reducing pain immediately after therapy (except in the study by Finn et al.[33], where placebo mirror therapy showed the opposite effect). However, the percentage reduction in pain intensity was lower than in the experimental groups. An exception was the study by Özcan et al.[39], where the control group showed better results in pain reduction than the experimental group (see Table 2).

Risk of bias and limitations

According to Cochrane's revised tool for assessing risk of bias in randomised trials RoB 2 (ref.[48]) were identified biases of reviewed studies, see Fig. 2.

Several limitations should be considered when interpreting the findings of this review. The generalizability of the findings may be limited due to the characteristics of the tested samples. Most studies focused on specific pain conditions such as phantom limb pain, adhesive capsulitis, impingement syndrome, and non-specific neck pain, which may not represent broader musculoskeletal pain populations. This diversity limits direct comparability and generalizability of findings across diagnoses.

Due to the nature of the interventions used, it is very difficult to blind the study participants or the therapists who provided the therapy. Therefore, many of the included studies reported that participants/therapists were aware of their inclusion in the experimental or control group.

Further limitation represents the variation in therapy duration, frequency or session length. The duration varied from 4 to 12 weeks, with some studies not specifying duration[32,34]. Frequency ranged from daily sessions[31,38] to 3 times per week[35,40], session length ranged from 5 min (ref.[38]) to 60 min including even the conventional thera-

	D1	D2	D3	D4	D5	Overall
Anaforoğlu Külünkoğlu et al. 2019 [31]	+	-	+	-	+	-
Baskaya et al. 2018 [32]	-	+	+	+	-	-
Finn et al. 2017 [33]	+	X	+	-	+	-
Mena-Del Horno et al. 2023 [37]	+	+	+	+	+	+
Hoyek et al. 2014 [34]	-	+	+	-	+	-
Javdaneh et al. 2021 [35]	+	-	+	+	+	-
Limakatso et al. 2020 [36]	+	-	+	+	+	-
Ol et al. 2018 [38]	-	-	+	-	+	-
Özcan et al. 2019 [39]	-	+	+	+	+	+
Öztürk et al. 2021 [40]	+	-	+	+	+	-

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgement
X High
- Some concerns
+ Low

Fig. 2. Risk of bias assessment for individual studies.

py[37]. These differences may influence treatment efficacy and complicate pooled analysis.

Also, the age of participants varied widely across studies, ranging from young adults (e.g., 19–20 years[39]) to older adults (e.g., median age 63 years[36]), which may affect the applicability of results to different age groups. Additionally, several studies showed imbalanced gender distributions, with some samples predominantly female (e.g. 90% female in the control group[39]) or male[33] potentially introducing gender-related bias and limiting generalizability across sexes. So, these factors should be also considered when interpreting the results and applying them to broader clinical populations.

Although quality of life is closely linked to the perception and experience of chronic pain, only four of the ten reviewed studies[31,32,36,39] explicitly assessed it as an outcome measure. Significant improvements in quality of life were reported in two of these studies[31,32]. The remaining studies[33–35,37,38,40] did not focus on quality of life, despite its relevance to chronic pain rehabilitation.

Patient adherence plays a pivotal role in the success of motor imagery interventions, especially those involving home-based or autotherapy components. However, most reviewed studies did not report adherence monitoring. Limitations of reviewed studies are listed below in Table 3.

Table 3. Limitations of included studies.

Limitation	Study	Ref.
Small sample size	Anaforoğlu Külünkoğlu et al. 2019	31
	Baskaya et al. 2018	32
	Finn et al. 2017	33
	Javdaneh et al. 2021	35
	Limakatso et al. 2020	36
	Özcan et al. 2019	39
	Öztürk et al. 2021	40
Absence of follow-up measurement	Baskaya et al. 2018	32
	Finn et al. 2017	33
	Özcan et al. 2019	39
	Öztürk et al. 2021	40
Wide age range	Baskaya et al. 2018	32
Heterogenous grouping	Baskaya et al. 2018	32
Participant population consisted mainly of females	Öztürk et al. 2021	40
Participant population consisted only of males	Finn et al. 2017	33
The study was designed to randomly assign participants to therapy instead of matching clinical characteristics	Finn et al. 2017	33
Therapy was provided in the subacute phase (less than 2 years since the amputation), when the intensity of PLP may decrease spontaneously over time	Anaforoğlu Külünkoğlu et al. 2019	31
Absence of the information about wash-out time for the medications prior to the study	Anaforoğlu Külünkoğlu et al. 2019	31
The number and duration of sessions in experimental group was higher than the frequency of application of therapy in control group	Anaforoğlu Külünkoğlu et al. 2019	31
Insufficient dosage and the length of the therapy intervention	Özcan et al. 2019	39
Excluding patients with confirmed sensorimotor changes, what may lead to difference on outcome measures	Özcan et al. 2019	39
No rehabilitation in control group for six weeks	Javdaneh et al. 2021	35
No blinding of participants with respect to group assignments	Javdaneh et al. 2021	35
Movement during MI was too complex to imagine or outside of the painful area	Hoyek et al. 2014	34
Minor deviation from study protocol was noted in	Ol et al. 2018	38
Cross-cultural differences (meanings of words in Khmer language and in English)	Ol et al. 2018	38
The re-allocation of crossover patients in the other subsample could be questioned	Ol et al. 2018	38
The lack of monitoring of treatment adherence	Limakatso et al. 2020	36
The restricted setting (Cape Town, South Africa)	Limakatso et al. 2020	36
A single treating clinician	Limakatso et al. 2020	36
A lack of post-trial blinding assessment	Limakatso et al. 2020	36
Lack of a sham treatment	Limakatso et al. 2020	36

It is important to acknowledge even the methodological limitations and other issues of this review when interpreting the results. The search strategy was limited to selected databases and did not include grey literature sources, which may have led to publication bias. Furthermore, only studies published in English were considered, potentially excluding relevant evidence from non-English publications. No automated tools were used to search the databases and analyse the results. There was no synthesis of the results, and this review is not a meta-analysis. The heterogeneity in sample characteristics and motor therapy protocols complicates the pooled analysis. The included studies allow for basic comparative analysis of pain outcomes; the absence of reported effect size estimates and confidence intervals limits the ability to assess the precision and clinical relevance of the findings. The heterogeneity of pain conditions, intervention protocols, and methodological quality across studies limits direct comparability and generalizability of the results. Recent meta-analyses have evaluated the effectiveness of MI and AO in the context of musculoskeletal pain[49-51]. In contrast, our scoping review aimed to map recent RCTs across an extended range of currently applied motor imagery techniques, categorized primarily by intervention type, with additional consideration given to the pain conditions. While these meta-analyses suggest promising therapeutic potential, they consistently report low certainty of evidence due to small sample sizes, high heterogeneity, and methodological limitations – issues that our review also identified as critical targets for future research.

Implications for clinical practice and future research

Motor imagery techniques – including motor imagery (MI), mirror therapy (MT), and graded motor imagery (GMI) – should be considered as adjunctive interventions in the rehabilitation of chronic musculoskeletal pain. Their application has shown promising results in conditions such as phantom limb pain[31,33,36], adhesive capsulitis[32,37], shoulder impingement syndrome[34], and non-specific neck pain[39]. These conditions are likely associated with central sensitization mechanisms, which motor imagery-based approaches may help modulate. Clinicians should tailor the choice of technique to the specific pain condition and ensure patient engagement through structured home programs.

Future research should focus on high-quality, double-blind RCTs with creative masking strategies, larger samples, standardized intervention protocols, and well-defined active comparators. Studies that stratify results according to pain status and include long-term follow-up are recommended. Additionally, the role of patient adherence and the neurophysiological mechanisms underlying differential responses to motor imagery techniques warrant further investigation.

CONCLUSION

A total of 10 imagery studies were included in the review. The majority of studies showed a significant reduction in perceived musculoskeletal pain using imagery in patients with (post-traumatic) phantom pain[31,33,36,37], adhesive capsulitis[32,37], impingement syndrome[34], non-specific neck pain[35,39] and gonarthrosis pain[40]. The main intervention used in the trials reviewed was mirror therapy or motor imagery combined with exercise, and it is not possible to determine which intervention was the most effective from the results of the included trials. In the experimental group, a decrease in the perception of pain intensity was mostly found immediately after the intervention and even 3–6 months after therapy, when assessed.

The effectiveness of motor imagery techniques appears to vary by pain mechanism. Conditions with neuropathic components (e.g., phantom limb pain) consistently demonstrated greater benefit than purely nociceptive conditions (e.g., osteoarthritis). This suggests that interventions targeting cortical reorganization may be most impactful in chronic musculoskeletal pain. Future research should focus on stratifying outcomes by pain mechanism, developing standardized protocols tailored to these subtypes, and probably further exploring neurophysiological markers that predict response. Such work is essential to optimize clinical application and guide personalized rehabilitation strategies.

All techniques based on the principle of motor imagery have considerable potential for the treatment of chronic musculoskeletal pain. However, there is a lack of high-quality, double-blind evidence with a sufficiently large number of participants. The body of RCT evidence included in this review is heterogeneous; therefore, this scoping review provides a broader overview and first insight into the effectivity of motor imagery techniques in the treatment of chronic musculoskeletal pain and may help guide the design of future systematic reviews/ clinical trials on this topic.

Motor imagery techniques show considerable promise as adjunctive therapies for chronic musculoskeletal pain, with neuropathic conditions demonstrating the most consistent benefit. To translate this potential into routine clinical practice, larger high-quality trials with standardized protocols are needed to confirm long-term effectiveness and guide personalized rehabilitation strategies.

Search strategy and selection criteria

The search strategy and selection criteria are described in detail in the Materials and Methods section. The review systematically searched four major databases using defined keywords. Studies were screened independently by two reviewers, and only randomized controlled trials (2013–2023) involving adults with chronic musculoskeletal pain were included. Eligible trials tested motor imagery techniques for pain reduction, with pain intensity measured numerically as the primary outcome. Full details of the search strategy and selection criteria are provided in the section Materials and Methods.

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