Models and frameworks of mental imagery training in medical education: A BEME scoping review

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Team members

1. Athar Omid, MD, PhD. Assistant professor, Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. E-mail: athar,omid@gmailcom. (Lead author)

   Her major area of interest is clinical teaching and most of her academic products have focused on this issue. She teaches clinical education in different faculty development courses and PhD course of medical education.
2. Mohammad Hossein Nilforoush. PhD candidate of Medical Education. Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. Email: mhnilforoush@gmail.com
3. Hamideh Montazeri. PhD candidate of Medical Education. Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. Email: hamidehmontazeri22@gmail.com
4. Samaneh Zangoee Dovvom. PhD candidate of Medical Education. Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. Email: s.zangoei2@gmail.com
5. Alireza Rahimi, Associate Professor, Medical Library and Information Sciences Dept, Isfahan University of Medical Sciences, Isfahan, Iran, His major area of interest is information management and medical informatics. Email: alirezarahimi.kh@gmail.com
6. Batool Eghbali, MD, PhD, Assistant Professor, Community Medicine Department, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran. Her major interest is management in the area of teaching-learning process. Email: b73.eghbali@gmail.com
7. Nikoo Yamani, MD, PhD, Associate professor, Department of Medical Education, Medical Education Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. Her major interest is in curriculum development and professionalism. She also works on faculty development and teacher evaluation. She teaches curriculum development courses to Phd students of medical education and nursing and also in faculty development courses. Email: nikooyamani@gmail.com

Abstract

Background: Mental imagery as a teaching strategy had been used in different fields like sports and medical education to promote the learning process. It is referred to by various names: mental imagery, mental practice, motor imagery, etc. On the other hand, it has been used in different forms (audiotape, voice and written scripts, …) and in some cases included an imagery relaxation. Also, different outcomes of its application, especially in medical education, have been reported such as promoting the procedural or clinical skills and reducing the stress level related to the clinical performance. Although there is some evidence of the various forms of mental imagery and its effects on improving learning outcomes in medical education, it is not sufficiently coherent. A systematic review of the literature could be helpful to provide best evidence in this regard.

Objective: This study is designed to find appropriate answers for these research questions: "which models or frameworks of mental imagery have been used in medical education?" and "what are the components and strategies of mental imagery that make learning effective in medical education?"

Methods: we will follow the five stages of a scoping review outlined by Arskey and O'Malley. Studies reporting the application of the mental imagery in medical education (undergraduate or postgraduate or CME) in English and Persian will be included with no restrictions regarding study design and publication date. A comprehensive search to find appropriate articles will be done considering the following: using related keywords found from the scoping or pilot search with a suitable search strategy, searching in the related databases and search engines, conducting forward and backward searching and trying to find gray literature in this context. Data extraction will be done independently by 2 contributors regarding the inclusion and exclusion criteria following these steps: deleting duplication, screening title and abstract, reviewing full papers, extracting data from the finally selected papers. In the case of any disagreements, a 3rd team member will resolve it.

Background

One of the most notable capacities of the mind is its ability to simulate one's experiences. In mental imagery or the cognitive simulation process, a person can represent perceptual information in his mind without any sensory stimuli(1). Another one, "motor imagery" (traditionally known as "mental practice"), a mental simulation process, is of more interest to cognitive neuroscientists and sports psychologists. Mental practice techniques can improve physical activities/skills through regular use of mental imagery. This was known as the "symbolic mental rehearsal" of a task without any real physical activity. Driskell explained "engaging in mental practice" as follows, thinking through a passage to prepare the musician for running the passage, or visualizing the steps of a sports activity to prepare the athlete for a sport event (2).

Although mental imagery is widely used in sports, it can also be used as a teaching strategy in medical education. There are many published studies related to the use of this strategy in the medical education especially for procedural skills. In these studies, different models and frameworks of mental imagery, as a way to promote learning, have been used. These models and frameworks are based on the activation of the mental imagination during the learning process with some differences in duration or format of the imagination. Rakestraw (1983) reported a 5-minutes audiotape of the correct performance of pelvic examination, developed to enhance learning clinical skills in medical students through mental practice (3). Another example is developing mental practice scripts regarding kinesthetic, visual and cognitive cues of the desired procedure to promote learning procedural skills in medical residents (4, 5). In some cases, an imagery relaxation is added to the mental imagery protocol (6, 7). Considering these different forms and their effectiveness helps medical educators to improve the teaching-learning process in medical education.

Scoping or pilot search of the primary researches on mental imagery

Several primary studies have evaluated the effectiveness of different models and framework of mental imagery and mental practice in medical education especially for training motor skills. We conducted a scoping search of these studies and the results of this review are shown in the appendix1.

Lessons learned from scoping or pilot search

The scoping search was helpful for developing the review protocol and developing a search strategy. Here are some informative tips from this scoping search.

- Mental practice and mental imagery are used interchangeably, but the two terms are different. Mental imagery represents any perceptual information in our minds in the absence of sensory input while mental practice is motor imagery. This technique mentions to the regular use of mental imagery in order to rehearse physical activities. By this definition, we will use the term mental imagery because we want to explore broader outcomes other than procedural skills.
- We realized that different studies have used various keywords for the instrument, including ‘Mental imagery rehearsal’, ‘Visual imagery’, ‘Mental imagery’, ‘Mental practice’, ‘Mental simulation’, ‘Mental training’, ‘Mentally picturing’, ‘Mental rehearsal’, ‘Mental work’, ‘Visualization rehearsal’, ‘Symbolic rehearsal’, ‘Covert rehearsal’, ‘Cognitive rehearsal’, ‘Conceptualizing’, ‘Conceptualization’, ‘Cognitive Imagery’, ‘Cognitive rehearsal’, ‘Imaginary practice’, Imaging, ‘Motor imagery practice’, ‘Psyching-up’, ‘Introspective rehearsal’, ‘Auditory imagery’, ‘Olfactory

imagery', 'Motor imagery', 'Cognitive training', and 'Brain training'.

- We also noticed that the studies have targeted different populations (Undergraduate, post-graduates, practicing physician, and so on) and have been conducted in different contexts.
- Different models and frameworks of mental imagery have been used in the studies. Timing, instruction, environment and …varied in different studies and in some cases included an imagery relaxation audiotape, voice or written scripts.
- Mental imagery has been used for different purposes and different outcomes have been evaluated. These outcomes include students' viewpoints on the process of mental imagery, quality of participants' imagery experiences, stress level, knowledge retention, skill acquisition, learning clinical skills and performance.

We used these lessons in developing our search strategy and also incorporated these findings in our data extraction form.

Previous systematic reviews

- Sara Davison et al published a paper entitled 'mental training in surgical education: a systematic review'. They searched EMBASE and Medline databases and examined surgical proficiency following training, training duration, forms of MT and trainees' level of experience. In this research fourteen trials with 618 participants met the inclusion criteria. They concluded that the majority studies demonstrate MT to be beneficial in surgical education. They emphasized that mental training for expert surgeons could be more effective than the medical students or the novice surgeons regarding surgical education (14).
- Rao et al published a paper entitled "Systematic review and meta-analysis of the role of mental training in the acquisition of technical skills in surgery". The aim of that study was evaluation the role of mental training in the learning surgical technical skills. They revealed that mental training can be used as an important supplementary tool in acquisition of surgical skills when applied to trainees with some experience of the skill (15).
- Corina Schuster et al published a paper entitled "Best practice for motor imagery: a systematic literature review on motor imagery training elements in five different disciplines" in 2011. They investigated the characteristics of a successful mental imagery training and compared these for different disciplines (education, music, medicine, psychology and sports). They concluded that in the Psychology literature, Successful design characteristics were in interventions focusing on motor, in interventions with participants aged 20 to 29 years old, and in mental imagery interventions including participants of both genders. They did not identify distinct characteristics in education (16).
- Huon Snelgrove and Ben Gabbott published a paper entitled "critical analysis of evidence about the impacts on surgical teams of 'mental practice' in systematic reviews: a systematic rapid evidence assessment" in 2020. They reviewed 6 systematic reviews to determine the impact of MP on surgical performance and learning. They concluded that the majority of studies demonstrated benefits of MP for technical performance (17).
- Hall J.C published a paper entitled "imagery practice and the development of surgical skills" in 2002. The purpose of this review was to explore the potential role of imagery practice during the acquisition of surgical skills. He conducted a literature search of a computer database (Medline). He concluded that imagery practice provides a mechanism for the explicit learning of surgical skills

and proposed a cyclical six-stage technique for explicit learning of surgical skills: task definition, prior learning, mental rehearsal, reflection, problem solving and reality check. In this review, the methodological procedure lacked a systematic approach (18).

- Another review in this area is not a systematic review but it also focuses on mental skills training in surgery. It revealed that mental imagery enhances surgical performance (19).

As mentioned in the previous paragraphs, we found some review articles related to the application of mental practice in medical education, mostly limited to the surgical performance. In another word the psychomotor domain of medical learning objectives is dominated in these studies compared to the other domains of cognitive and affective. On the other hand, the wide spectrum of medical specialties is not included in the mentioned reviews. So, it seems that a systematic review containing more widespread domains of learning objectives and all medical specialties is needed. Furthermore, none of these reviews have analysed the design of the mental imagery training session to determine successful mental imagery intervention techniques, such as the number and duration of MI trials, and the instruction mode and type. However, the design of the mental imagery training session is of vital importance for medical teachers to implement mental imagery interventions. In this systematic literature review, we will extract and analyze different models and frameworks of mental imagery training session that led to effective learning in medical education.

Review questions, objectives and keywords

In this review, we intend to find convincing answers to the following questions:

- Which models or frameworks of mental imagery have been used in medical education?
- What are the components and strategies of mental imagery that make learning effective in medical education?

Considering the results of our scoping search, we have identified the following keywords for this BEME review:

Population:

- Undergraduate medical trainee, Undergraduate medical education, basic medical education, Medical student
- Postgraduate medical trainees, graduate medical education, residency training, resident, Continuing medical education, CME, Continuous Medical Education, Continuing Professional Development, CPD

Intervention:

- ‘Mental imagery’, ‘Mental practice’, ‘Mental simulation’, ‘Mental training’, ‘Mentally picturing’, ‘Mental rehearsal’, ‘Mental work’, ‘Mental imagery rehearsal’, ‘Visual imagery’, ‘Visualization rehearsal’, ‘Symbolic rehearsal’, ‘Covert rehearsal’, ‘Cognitive rehearsal’, ‘Conceptualizing’, ‘Conceptualization’, ‘Cognitive Imagery’, ‘Cognitive rehearsal’, ‘Imaginary practice’, Imaging, ‘Motor imagery practice’, ‘Psyching-up’, ‘Introspective rehearsal’, ‘Auditory imagery’, ‘Olfactory imagery’, ‘Motor imagery’, ‘Cognitive training’, and ‘Brain training’
-

Comparison:

- Traditional methods or Traditional techniques (study textbook, lecture, watching a video

or …)

Outcome:

- Reaction
- Learning: change in attitudes or change in knowledge or skills
- Behavior: change in behavior

For the purpose of this study, the above-mentioned keywords would be defined as follows:

- Undergraduate medical trainees are students undertaking undergraduate or basic medical education at a medical school in order to reach a primary qualification in medicine.
- Postgraduate medical trainees are learners of educational programs for medical graduates entering a specialty. They include formal specialty training as well as academic work in the clinical sciences.
- Mental imagery: In mental imagery or the cognitive simulation process, a person can represent perceptual information in his mind without any sensory stimuli. Mental imagery is the simulation or re-creation of perceptual experience across any sensory mode (20). Thus, we have the capacity to imagine "seeing", "hearing", "tasting", "smelling" and "feeling" simulated actions and experiences (1).
- Mental practice: Mental practice defined as "the cognitive rehearsal of a task in the absence of overt physical movement" (2) or the act of performing motor tasks in the 'mind's eye' (14). For example, in mental practice a musician practices a passage by thinking it through or an athlete prepares for an event by visualizing the steps required to perform the task. In essence, the performer systematically uses mental imagery to rehearse a skill [(14)]. Mental practice typically is performed in a period of relaxation exercises, followed by an expert educator reciting a mental imagery script with emphasis on visual, kinesthetic and cognitive cues.
- Learning outcome and effectiveness: A modified version of Kirkpatrick's classification of training outcomes (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005) (Freeth, Hammick, Reeves, Koppel, & Barr, 2005) adopted by the BEME collaboration as a grading standard for systematic reviews, (Hammick, Dornan, & Steinert, 2010), will be used to classify the outcomes during the data extraction of program evaluation (21-23). These levels are listed in table 1.

Table 1: Kirkpatrick's classification of training outcomes

Level1	Reaction
Level2A	Learning- change in attitudes
Level2B	Learning – change in knowledge or skills
Level3	Behavior-change in behavior (self-evaluation/observation)
Level4A	Results-change in professional practice

Level4B	Results-benefits to patients

For our review, effectiveness will be interpreted with the outcomes such as the following:

- Level1: Participant satisfaction with the quality of mental imagery, self-reported confidence improvements, self-reported stress management
- Level2A: A before and after study may show that changes in participants' perceptions and attitudes toward mental imagery and increase motivation have occurred.
- Level2B: Modification of knowledge/skills (acquisition of knowledge, clinical skills, procedural skills, teamwork skills and …)
- Level 3: Changes in participants' performance in the workplace (clinical skills, procedural skills, team performance and …)

In this study, only the outcomes of the first three levels will be considered.

- Models and frameworks of mental imagery training session: Hall J.C proposed a cyclical six-stage technique for explicit learning of surgical skills through mental practice: task definition, prior learning, mental rehearsal, reflection, problem solving and reality check (18). In another study Holmes and Collins introduced the PETTLEP framework (physical, environment, task, timing, learning, emotion and perspective). This framework facilitates designing MI interventions for athletes and building on findings in functional neuroscientific research literature. PETTLEP framework comprises seven components. Component of this framework include: physical position of the person, the environment that has to be imagined, the task involved, the timing or duration, the learning or changes that occur during imagery, the emotions that are associated with the task, and imagery perspective (24). In this study, we will use a combination of these two models and perform the analysis based on the six-stage technique of the Hall's model and the components of the PETTLEP framework. The Hall's model will be used to analyze activities before and after mental imagery and PETTLEP framework will be used to analyze elements of mental imagery.

Methods

This protocol has been guided by BEME guidance and the model for scoping reviews described by Arksey and O-Malley (25). The five stages of a scoping review that we want to fulfill are as following:

Stage 1: identifying the research question (as above)
Stage 2: identifying relevant studies
Stage 3: study selection
Stage 4: charting the data
stage 5: collating, summarizing and reporting the results

Search sources and strategies

Different approaches and methods will be used to enhance the comprehensiveness of our search. In addition to electronic search in bibliographic databases, we will conduct forward and backward searching by

checking the reference lists and citations of the included articles for additional relevant studies. We will also contact leading authors in the field of mental imagery. Moreover, in order to find the grey literature, we will search ProQuest Dissertations & Thesis and OpenGrey.
The following databases will be explored:

- MEDLINE/PubMed
- Proquest
- Science Direct
- Clinical Key
- EMBASE
- Cochrane Library
- ERIC
- Springer
- SCOPUS
- Web of Sciences
- Magiran
- MOH Articles
- MOH Thesis

We conducted a scoping search in Pubmed to help us make decisions on the final search strategy. While the following free search strategies were generally supposed to include the population, activity and outcomes, at first, we performed our scoping search only by including mental imagery and its related terms, because we presumed that the number of primary studies on the mental imagery would not be substantial. So, we assumed that searching in both Title and Keywords fields including population (i.e. undergraduate and postgraduate medical trainees), limit the number of retrieved articles and improve specificity of the following search strategies.

("Mental practice" OR "Mental imagery" OR "Mental simulation" OR "Mental training" OR "Mentally picturing" OR "Mental rehearsal" OR "Mental work" OR "Mental imagery rehearsal" OR "Visual imagery" OR "Visualization rehearsal" OR "Symbolic rehearsal" OR "Covert rehearsal" OR "Cognitive rehearsal" OR Conceptualiz* OR "Cognitive Imagery" OR "Cognitive rehearsal" OR "Imaginary practice" OR Imagin* OR "Motor imagery practice" OR "Psyching-up" OR "Introspective rehearsal" OR "Auditory imagery" OR "Olfactory imagery" OR "Motor imagery" OR "Cognitive training" OR "Brain training") AND ("undergraduate medical trainee*" OR "undergraduate medical education" OR "basic medical education" OR "medical student*" OR "postgraduate medical trainee*" OR "graduate medical education" OR "residency training" OR resident* OR "Continuing medical education" OR CME OR "Continuous Medical Education" OR "Continuing Professional Development" OR CPD) in TITLE

("Mental practice" OR "Mental imagery" OR "Mental simulation" OR "Mental training" OR "Mentally picturing" OR "Mental rehearsal" OR "Mental work" OR "Mental imagery rehearsal" OR "Visual imagery" OR "Visualization rehearsal" OR "Symbolic rehearsal" OR "Covert rehearsal" OR "Cognitive rehearsal" OR Conceptualiz* OR "Cognitive Imagery" OR "Cognitive rehearsal" OR "Imaginary practice" OR Imagin* OR "Motor imagery practice" OR "Psyching-up" OR "Introspective rehearsal" OR "Auditory imagery" OR "Olfactory imagery" OR "Motor imagery" OR "Cognitive training" OR "Brain training") AND ("undergraduate medical trainee*" OR "undergraduate medical education" OR "basic medical education" OR "medical student*" OR "postgraduate medical trainee*" OR "graduate medical

education" OR "residency training" OR resident* OR "Continuing medical education" OR CME OR "Continuous Medical Education" OR "Continuing Professional Development" OR CPD) in KEYWORDS/SUBJECT/MESH

Study selection

Table 2 shows the inclusion and exclusion criteria of this study.

Table 2: Inclusion and exclusion criteria

	Inclusion Criteria	Exclusion criteria
Population	Studies on undergraduate or postgraduate medical trainees Studies on CME or CPD	Studies on non-medical students
Intervention	mental imagery for education	mental imagery for treatment mental practice to teach music and sports mental practice for non-educational purposes
Outcome	We will consider Kirkpatrick model: Reaction, Learning (Skill, Knowledge, Attitude), Behavior, performance, impact	
Comparator	All comparators of interventions, will be considered	
Language	Persian and English	Other languages except Persian and English
Type of study	All designs of quantitative research and qualitative research	Papers describing non primary empirical research (Letters and editorial papers) and review articles
Publication date	No restriction	

The following studies will be included:

- Population:
    - Studies on undergraduate and postgraduate medical students (defined as ‘students undertaking a course of study at a medical school in order to reach a primary qualification in medicine, enabling them to practice as doctors’).
    - Studies on Continuous Medical Education/Continuing Professional Development (CME/CPD)

- Intervention: Mental Imagery, Mental training, Mental practice, Cognitive imaging, Practice Schema
- Comparator: All comparators of interventions, if present, will be considered.
- Outcome: we will use a modified version of Kirkpatrick model as above
- Language: Studies in English or Persian
- Study design: All designs of quantitative research and qualitative research

- No restrictions on publication date

The following studies will be excluded:

- Studies on trainees of disciplines other than medicine
- Studies describing non primary empirical research
- Studies using mental imagery for treatment
- Studies that used mental imagery to teach music and sports.
- Studies that used mental imagery for non-educational purposes.
- Studies in languages other than English or Persian (Because the review of the full text of national and international studies by the research team can be possible only in English and Persian languages so the other ones will be excluded. In spite to aforementioned issue any published studies with abstract written in English is accepted to be reviewed if they show the necessary data.)

Charting the data

We have designed a data extraction form to extract data from the primary studies. This form is shown in table 3.

Table 3: The primary version of the data extraction form

	Paper code
	First author
	Publication year
	Language
	Country
	Title of the study
	Research question
	study method
	Target population
	Name of Course (the topic)
	Sampling method
	number of samples
	Type of participation
	Model and framework of mental imagery (stages based on Hall's model)
	Elements of mental imagery based on PETTLEP framework)
	Method in compare group
	study Site
	The duration of the intervention (number of hour and meeting)
	Tools (paper tools or electronic tools)
	Tool validity& tool reliability
	Time for mental imagery and Time lag between mental imagery delivery and task
	One-on-one with mental imagery educator or team based
	Assessment of mental imagery
	Effect on level1(P value and effect size)
	Effect on llevel2A (P value and effect size)
	Effect on level2B (P value and effect size)
	Effect on level3 (P value and effect size)

This template might be revised after checking the selected articles by the team consensus meeting. The reliability of this form will be checked before starting the extraction by calculating Kappa coefficient for each item. For this purpose, two authors independently review 10 articles using this form, and the Kappa coefficient will be calculated for each item. Kappa coefficient for each item must be 0.7 or higher; otherwise, the item will be modified or rechecked to prepare the final form.
Two reviewers (MN&HM or SZ&BE) independently will screen each paper in two rounds. The initial screening process will perform based on the titles and abstracts of the papers. In the second round, the full texts of the remaining articles will assess against the inclusion and exclusion criteria. Two independent coders (NY& BE) will analyze each study and extract all data based on the final form. In case of any disagreements regarding inclusion and quality of the study, the coders will be asked to discuss the issue with each other. However, if the disagreement cannot be resolved, a third reviewer (AO) will be consulted. The third reviewer will independently extract data, and then discuss with two coders to reach consensus. If consensus cannot be reached, they will contact with the study authors for further information, and the final decision will be made. The consistency between coders will be checked through calculating Kappa coefficient for each item.

Collating, summarizing and reporting the results

We will extract and analyze different models and frameworks of mental imagery training session that led to effective learning in medical education; in this regard we could be able to answer the research questions. Qualitative data synthesis and tabular presentation of research methods and outcomes were used. Included papers will be coded regarding study details of context, methods, intervention and review results or outcomes; then, a narrative will be written for each one.

The reported mental imagery training session will be coded based on six-stage technique of the Hall's model and the components of the PETTLEP framework. The Hall's model will be used to analyze activities before and after mental imagery and PETTLEP framework will be used to analyze elements of mental imagery. The reported outcomes will be categorized based on the Kirkpatrick's Evaluation model. Then, based on analysis of the outcomes, all studies will be classified into two categories: positive change, and no or negative change. Finally mental imagery training session elements for mental imagery interventions with positive results versus no changes or negative will be discussed and compared with the findings of neuroscientific research literature and research findings in other disciplines such as sports and medicine. Considering scoping search, we predict significant heterogeneity among the studies; this feature will preclude conducting meta-analysis.

Translation into practice

We will determine successful mental imagery intervention techniques, such as the physical position of the students, the environment that has to be imagined, the timing or duration, and the instruction mode and type. If the effectiveness of different models and framework of mental imagery is proven, it can be recommended to improve the learning outcomes in undergraduate and postgraduate medical education. However, the design of the mental imagery training session is of vital importance for medical teachers to

implement mental imagery interventions. We expect that by conducting this review we will be able to identify knowledge gaps in this field and suggest areas for future research.

Project timetable

The Gantt chart is shown in table 6 (from 1 July 2021 to 31 December 2022):

Table 6: Project timetable

	July-September 2021	**October 2021-February 2021**	**April-August2022**	**September-December 2022**
Searching	*			
Data extraction& coding		*		
Data synthesis			*	
Preparing the manuscript				*

Conflict of interest statement

The contributors declare that they have no competing interests.

Plans for updating the review

We intend to update this research after three years of the date of the review.

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Appendix 1: The results of scoping or pilot search

No	title	year- 1st author	study question/aim	participants	Intervention	Comparison	Outcome	results
1	Development and Validation of a Mental Practice Tool for Total Abdominal Hysterectomy(5)	2017- Said S. Saab	To develop and validate a mental practice tool (MPT) in the subject of total abdominal hysterectomy (TAH) for resident training.	Obstetrics and gynecology (OBGYN) residents and attendings.	A mental practice script regarding kinesthetic, visual and cognitive cues of the desired procedure (TAH) was developed.	No control groups.	For validation, participated residents and attendings filled out a Mental Imaginary Questionnaire before and after exposure to the MPT. Maximum time of exposure was 30 minutes.	These factors were assessed for validation of the MPT: Motivation, confidence, quality of imagery, and utility of the activity. According to this assessment, the developed MPT is useful for learners. A linear relationship between the usefulness of MPT and previous experiment of TAH, suggests that fewer experiments is associated with more learning; However, this is not statistically significant.
2	Mental practice with interactive 3D visual aids enhances surgical performance(8)	2017- Marina Yiasemidou	To assess if the interactive 3D models of the task-relevant anatomy, during MP could facilitate the process and subsequently impact on performance in trainee surgeons.	Surgery residents	Intervention groups 1 and 2: participating in a single 25-minutes Mental Preparation (MP) session (visualise and feel the operation) with a facilitator, Intervention group 2: incorporating an interactive 3D model of the relevant surgical anatomy into the MP process.	Control group: watching a didactic real time video of Laparoscopic Cholecystectomy (LC)	Performance: Laparoscopic Cholecystectomy (LC)	Performance metrics with statistically significant improvement in intervention groups: ✓ Time ✓ Total number of movements ✓ Path length Safety metrics with no statistically significant differences in intervention groups: ✓ Number of perforations ✓ Frequency of non-cauterised bleeding ✓ Damage to vital structures
3	Mental practice: a simple tool to enhance team-based	2016- Gianni R. Lorello	to examine the effect of 20 minutes of structured mental practice (MP) on team performance	Anaesthesiology, emergency medicine,	MP group: 20 minutes of MP (including visual, cognitive, and kinesthetic cues), visualizing a trauma	Control group: 20 minutes of Advanced Trauma Life Support (ATLS)	Performance: participating in a high-fidelity adult trauma simulation.	The median score for MP group was significantly more than the control group.

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	trauma resuscitation(4)		in a simulated trauma resuscitation.	and surgery residents	scenario and their behavior and function in that situation.	face to face training.	Measurement: trauma teamwork performance	
4	Make a Personal Anatomical Atlas in Your Mind with Mental Imagery and Improve Your Active Learning of Human Anatomy(9)	2016- Noorafshan A	To apply "mental imagery" or "mental modeling" in teaching anatomy to medical students.	first-and second-year medical students	Reconstructing a mental anatomical model by students regarding these steps: - watching gross anatomy of the target organ - observing the related slides - assuming their body without that organ - placing the organ structures in their mental model step by step	No control groups	Assessing the students' viewpoints on the process of mental imagery.	According to most students this method makes: - learning anatomy easier - the anatomy class more active and less boring - remembering and recalling the anatomical concepts easier.
5	E-learning optimization: the relative and combined effects of mental practice and modeling on enhanced(10) podcast-based learning—a randomized controlled trial(10)	2016- Fahad Alam	To assess if the MP and the modeling (alone or in combination) could enhance learning airway management in medical students.	medical students- years 1 to 4	Mental practice group: narrated presentation with guided mental practice. Modeling group: narration with video demonstration of skills. Combined group: modeling and mental practice. The time of interacting with the learning content was equal in all 4 groups.	Control group: narrated presentation.	Assessment: Day one: Baseline MCQ. Day seven: MCQ (Knowledge retention) and a 10-min, manikin-based simulated airway crisis scenario (skills acquisition).	Knowledge retention was significantly higher in the combined and modeling groups than the others, also it was significantly higher in the modeling and mental practice groups than the control group. Scores related to the skills acquisition in the control group was significantly lower than the others. The combined group showed better improvement on the key events checklist in comparison to each of the modeling and mental practice group.

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6	Mental practice in postgraduate training: a randomized controlled trial in mastoidectomy skills(11)	2016- Anne Conlin	1) To develop and evaluate a mental practice (MP) protocol for mastoidectomy 2) To assess the impact of mental practice on mastoidectomy surgical skills among senior residents.	senior Otolaryngology─Head & Neck Surgery (OHNS) residents	1) Development: Mental practice protocol was developed regarding visual, cognitive and kinesthetic cues related to the procedure. 2) Intervention: Mental practice group: - brief relaxation - introduction to the concept of MP - listening to the MP script; it was also possible to read the written copy of the script and/or view the detailed illustrations.	Control group: Textbook Study	Skill acquisition: - baseline mastoidectomy -second mastoidectomy 48 hour after the intervention	1- mental practice protocol was developed. 2- Regarding Total Task-specific Evaluation for Mastoidectomy Score, the MP group had a no significant post-intervention higher score than the textbook study group. Each group had a non-statistically significant higher total score post-intervention than pre-intervention.
7	Randomized clinical trial to evaluate mental practice in enhancing advanced laparoscopic surgical performance(12)	2014- M. Louridas	1) To develop a mental practice script. 2) To assess its effect on advanced laparoscopic skills and surgeon stress levels in a crisis scenario.	senior surgical trainees	1) Developing mental practice scripts regarding the visual and the kinesthetic cues of the procedure. 2) Intervention: Mental practice group: - participating in a didactic lecture and receiving the instructional videos. - mental practice training: relaxation exercise, MP guided by the MP scripts required to 'feel' and 'see' each step of the laparoscopic JJ. - performing independent MP at home using the written scripts and the	Control group: participating in a didactic lecture and receiving the instructional videos.	Skill acquisition (JJs) and stress level: - baseline technical skill and stress level - participating in a crisis scenario of the target procedure after the intervention.	1) Mental practice script was developed. 2) Regarding OSATS (Objective Structured Assessment of Technical Skill) and BOSATS (bariatric Objective Structured Assessment of Technical Skill) scores, technical skills improvement in the MP group was significantly higher than the conventional training group. There were no significant differences between the two groups in terms of stress level based on the blood pressure, heart rate, and State–Trait Anxiety Inventory (STAI) score.

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					technical skills videos including a voice-over of the MP scripts for 7 days. - participating in 3 voice-recorded follow-up telephone calls to receive structured feedback.			
8	Mental Practice: Effective Stress Management Training for Novice Surgeons(13)	2011- Sonal Arora	To determine if the mental practice (MP) could reduce stress in novice surgeons.	novice surgeons	Performance: Five laparoscopic cholecystectomies (LCs), (1 LC per day) Mental practice (MP) group: 30 minutes of MP by the use of the MP training protocol before each LC.	Control group: 30 minutes of an unrelated online activity before each LC.	Stress level: - measuring baseline levels of stress based on the State–Trait Anxiety Inventory (STAI) score, heart rate and salivary cortisol. - measuring stress level before and after each LC.	Based on the pre-task and post-task cortisol, the MP group showed significantly lower stress level than the control group.
9	Development and validation of mental practice as a training strategy for laparoscopic surgery(6)	2010- Sonal Arora	To develop and validate a mental practice (MP) script for laparoscopic cholecystectomy (LC).	Novice and experienced surgeons	Developing MP script focusing on the visual, cognitive and kinesthetic cues. Intervention: Doing MP training based on the predetermined protocol (including relaxation, video of procedure, MP with talk-out).	No control groups.	Assessing the quality of participants' imagery experiences using the mental imaginary questionnaire (MIQ) before and after the training.	MP script was developed and validated. Novice surgeons showed a significant improvement in all items of the MIQ after the MP training. This improvement in experienced surgeons was significant for items 3, 4, and 7 of the MIQ that are relating to the confidence and kinesthetic imagery.
10	Learning basic surgical skills with mental imagery: using the simulation	2008- Charles W Sanders	To compare the effects of the mental imagery (MI) and textbook study on	Year 2 medical students	MI group: 30 minutes of guided imagery relaxation and rehearsal session. Study procedure:	Textbook study group: 30 minutes of studying based on the 'cloze' procedure.	learning of basic surgical skills: Cutting an incision and suturing a pig's foot	There were no significant differences between the 2 groups in the 1st and 2nd grade scoring. However, the MI group showed a significant higher score in the 3rd

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	center in the mind(7)		the learning of basic surgical skills.		- lecture - MI and textbook study - grade 1 scoring - 1-hour physical practice - grade 2 scoring - second session of MI and textbook study 2 weeks later - grade 3 scoring 10 days later.		(grade 1 & 2) and on the rabbit's side (grade 3)	grade scoring compare to the textbook study group.
11	The Use of Mental Practice in Pelvic Examination Instruction(3)	1983- Phillip G. Rakestraw	To determine the effects of mental practice on learning sequencing and clinical skills of a pelvic examination	Second year medical students	Audiotape: 5-minutes oral description of the correct performance. Mental practice groups: - premotor plan tape: listen to the audiotape before practicing on the Gynny model. - postmotor plan tape: listen to the audiotape after practicing on the Gynny model.	Usual instruction: - initial instruction of pelvic examination. - practicing pelvic examination on a pelvic model (Gynny model). - actual pelvic examination (trained patients). Control group: previously received usual instruction.	Learning clinical skill: - to list the examination sequence - to record the appropriate examination findings	The mental practice groups had a significantly higher scores on the ability to list the correct examination sequence and to record the actual examination findings.