

BEME GUIDE

Teaching musculoskeletal clinical skills to medical trainees and physicians: A Best Evidence in Medical Education systematic review of strategies and their effectiveness: BEME Guide No. 18

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Abstract

Background: Musculoskeletal (MSK) complaints make up 12–20% of primary health visits and are a source of significant expenditures and morbidity. Despite this, MSK examination is an area of weakness among practising physicians. Several studies have highlighted the need for increased MSK physical exam teaching. However, increased teaching time alone does not guarantee improvement in these skills. Thus, we aimed to identify interventions that are effective in promoting transfer of MSK clinical skills.

Methods: The review protocol was approved by the Best Evidence in Medical Education (BEME) organization. A comprehensive search was conducted and systematic review methods were applied. Data were not pooled statistically due to heterogeneity.

Results: About 5089 titles were screened; 24 studies were included. Eighteen of 24 studies focused on undergraduate medical education. Five of nine studies favoured patient educator. Five of six studies favoured interactive small groups, two of four studies favoured computer-assisted learning, and two of two studies favoured peer learning. Individual studies demonstrated effectiveness of reminder sheets and Gait Arms Legs Spine teaching, respectively.

Conclusions: This study supports the use of different instructional methods that engage learners and provide meaningful learning contexts. The majority of the studies support patient educators and interactive small group teaching.

Background

Musculoskeletal (MSK) complaints make up 12–20% of primary health care visits in Canada (Badley et al. 1994; Badley et al. 1995; Pinney & Regan 2001; Wang & Badley 2003) and are a source of significant health care expenditures (Yelin et al. 2001, 2004) and population morbidity (Badley et al. 1995; Badley & Wang 2001; Leroux et al. 2005). Current data project increases in both the prevalence of arthritis-related diseases and associated disability as the population ages (Badley & Crotty 1995; Badley & Wang 1998). Increasing levels of obesity are also likely to alter the future prevalence of MSK-related disorders. Despite this, MSK examination is often neglected in clinical practice (Rigby & Oswald 1987; Doherty et al. 1990; Ahern et al. 1991; Crotty et al. 1993), in contrast to near 100% documentation of cardiovascular, respiratory and gastrointestinal systems' examination (Doherty et al. 1990; Crotty et al. 1993).

Several previous studies and reports have raised concerns regarding the inadequacy of MSK clinical skills teaching, including recent reports from the American Association of Medical Colleges and the Collège des Médecins du Québec that have identified MSK clinical skills as areas of weakness in medical school curricula and among practising physicians

Practice points

- Effective MSK clinical skills teaching interventions maximize engagement and realistic context
- When choosing MSK clinical skills teaching methodologies, consider patient educators, interactive small group learning and CAL
- This review supports curriculum planners who are already implementing the strategies reviewed and assists those who strive to maximize teaching efficiency with limited instruction time and resources

(College des Medecins du Quebec Practice Enhancement Division 1999; Association of American Medical Colleges 2005). In addition, consensus statements from the UK (Dacre et al. 1996), the USA (Anderson et al. 2001) and the International League Against Rheumatism (Dequeker & Rasker 1998) underscore the need for not only more general physical exam (PE) teaching, but specifically more MSK PE teaching in medical school. As Woolf (2007) describes, 'there is a range of specialties involved in the management of the spectrum of MSK conditions, including rheumatology.

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orthopaedics, pain physicians, geriatrics, sports medicine, and occupational medicine'; however MSK clinical skills are seldom taught in an intra-disciplinary manner. As there have been no publications to date reviewing the strategies employed to teach MSK clinical skills within medicine, the authors chose to perform a review at this level of inquiry to provide a comprehensive evidence-base in this area for medical curriculum developers. As a part of the Bone and Joint Decade, the Association of American Medical Colleges published a detailed report in 2005 highlighting the under-representation of MSK in medical school curricula, specifying the recommended objectives that should be a part of all medical school MSK curricula and providing some broad suggestions of how they may be achieved (Association of American Medical Colleges 2005). Almost concurrently in 2006, the Alliance for the Canadian Arthritis Program (ACAP), published a report stating that 'all relevant health professionals must be able to perform a valid, standardized, age appropriate musculoskeletal screening assessment' (Alliance for the Canadian Arthritis Program 2006).

In addition to consensus statements, several surveys have demonstrated poor confidence by trainees in MSK clinical skills. For example, Clawson et al. (2001) performed one of the largest surveys of trainees entering residency in the USA and found that those from allopathic medical schools described themselves as poorly prepared to assess and treat common MSK complaints. Another recent survey of medical students at Harvard University revealed that although the students considered MSK medicine as the third most important topic to their future medical career, they described low to average levels of confidence in MSK examination skills; further, when these students were administered Freedman's nationally validated MSK basic competency short answer exam, only 26% of fourth year students passed (Day et al. 2007). Even when this exam was given to another population of trainees who came from a school with a longstanding dedicated MSK program, still a little more than 50% of the trainees failed the exam (Schmale 2005).

There are two issues that emerge from these data. First, there is little doubt that the teaching of MSK clinical skills in current undergraduate medical school curricula needs to be improved. However, simply adding teaching hours does not guarantee improvement in students' MSK clinical skills. This can only be achieved through better understanding of what teaching strategies are most effective at achieving competency in MSK clinical skills.

Small group learning has long been employed as a strategy for imparting clinical skills from expert clinicians to medical trainees. Such teaching sessions often have a range of objectives and may take place in a variety of environments, from the classroom to the bedside. However, all are grounded in the notion that Ericsson's (2004) educational principle of deliberate practice with expert feedback is more consistently executed in a small group rather than large class setting.

Within the past 25 years, many medical curricula have adapted small group interactive teaching sessions as one way to incorporate patients as educators. Many institutions now use patient educator programs, wherein trained patients take on an active role in the training of medical students and residents. This teaching strategy is well aligned with the educational

concept of a patient-centred approach to clinical skills teaching. A recent review of this subject found that the rationale for such programs is largely based upon the theoretical concept of the patient as an expert in their disease, which renders them a suitable and valuable teacher while also providing a meaningful clinical context for the material (Jha et al. 2009).

Traditional curricula have further evolved in response to advancing technological capacity, resulting in the development of computer-assisted learning (CAL) programs. CAL refers to the use of computer-based programs for the enhancement of student knowledge and performance, often through interactive teaching strategies. Authors have noted that CAL is considered a beneficial tool because it is flexible and convenient, offers unique presentation of information and encourages personalized and self-directed learning (Greenhalgh 2001). Researchers have generally concluded that CAL is an intervention that is equal to or better than traditional teaching methods in terms of student satisfaction and knowledge gain (McNulty et al. 2009).

While there is a large volume of literature regarding patient educators, small group learning interventions and CAL, there has not been a systematic evaluation of these interventions specific to the teaching of MSK clinical skills. We undertook a systematic review to identify and describe the research evaluating the effectiveness of different teaching strategies for MSK clinical skills.

Methods

Research question

The objective of this systematic review is to identify which structured educational interventions lead to competence in musculoskeletal clinical skills for medical trainees, including undergraduates, residents and practising physicians. The following outcomes were chosen *a priori* according to Kirkpatrick's (2006) model to assess the effectiveness of educational strategies: patient outcomes, change in behaviour, change in skills, change in knowledge and change in attitudes/perceptions. Reviewers aligned the outcomes of included studies according to this model.

For the purpose of this review, the MSK system is defined as the peripheral and axial skeletons and associated bone, muscle, tendon, ligament, joint, bursa and cartilage. Clinical skills are defined as patient history and physical examination, and do not include diagnostic imaging interpretation or procedural skills such as joint injection techniques.

Search strategy

A comprehensive search strategy was developed by a medical librarian (SC) in consultation with the remaining authors to identify relevant studies in the online databases listed in Table 1.

The specific terms and search strategies can be found in Table 2. In addition, the reference lists of all included studies were hand searched, as were those of relevant reviews that were identified during the title screening procedure

described below. We also hand-searched the conference proceedings for the Association of American Medical Colleges and the Association of Medical Education in Europe from 2006 to 2008. A separate cited reference search was also conducted using Web of Science for each included study looking for papers that cited it and that it cited. The primary authors of all included studies were contacted by email to determine if they knew of any unpublished, recently published or ongoing studies relevant to the review. The contact information used was extracted from the included papers or from the university directories associated with the primary authors.

Screening and selection of studies

The titles and abstracts generated from the electronic database searches were independently collected in a Refworks reference management database. They were then screened by two reviewers (AEO and AOO) to exclude those that obviously did not meet the inclusion criteria or address the question under study. The full texts of the remaining studies were retrieved and a pre-approved inclusion form was applied to each to identify relevant studies. This was done independently by two reviewers (AEO and AOO), and any disagreements that arose were resolved through discussion, or with the aid of a third reviewer (LH) as required.

Table 1. Included online databases.

| | |
|--|--|
| Medline (1950–present) | Cochrane Library (various dates – present) |
| EMBASE (1980–present) | SCOPUS (1823–present) |
| PubMed (1950–present) | Web of Science (1956–present) |
| CINAHL (1937–present) | ERIC (1966–present) |
| Sport Discus (1970–present) | OpenSigle (various years – present) |
| Google (dates of content vary – present) | Proquest Dissertations and Theses (content dates vary – present) |

Note: Databases – note that all searches were limited from 1970 to current (August, 2009).

The inclusion criteria are detailed in Table 3. These were applied to each potentially relevant study to evaluate whether the study should be included in the review. This review primarily focused on medical trainees who experienced structured teaching interventions as evaluated by controlled studies.

Assessment of methodological quality

The methodological quality of included studies was evaluated independently by two reviewers (LH and AOO) using well-recognized tools specific to different study designs. The Cochrane Risk of Bias tool was used for controlled trials (Higgins & Green 2008). The Newcastle–Ottawa Scale was used for cohort studies (Wells et al. 2010). These tools had been piloted in a previous systematic review performed by the authors (Hartling et al. 2010). Discrepancies were resolved through consensus.

The methodological quality of the included studies was summarized by grouping according to study design (cohorts vs. trials), and identifying common and methodologically significant areas of weakness.

Data extraction

Electronic data extraction forms were developed and piloted in a previous systematic review performed by the authors (Hartling et al. 2010). These forms were further revised and tailored to the current review through discussion within the review group after data from a sample of initial articles' was extracted. One reviewer extracted data (AOO), but to ensure accuracy and consistency of the process, a sample of 20% of the articles was randomly selected for extraction by a second reviewer (AEO). The data extracted by the two reviewers were then compared and no significant discrepancies or errors were detected. Age and gender were not recorded at the data extraction level, as the included studies did not consider these

Table 2. Search terms and strategy.

| Search Strategy | | |
|--|-----|--|
| Concept 1 | AND | Concept 2 AND Concept 3 |
| Medical education methods | | Clinical Musculoskeletal |
| exp Teaching/mt [Methods] or exp Medical Education/[Methods] or exp Programmed Instruction as Topic/ or exp Educational Measurement/or exp Curriculum/ or instructional methods.mp. or exp Computer-Assisted Instruction/ | | Exp Clinical Competence/or clinical.mp. musculoskeletal.mp. or exp Musculoskeletal System/or exp Musculoskeletal Development/ or exp Musculoskeletal Abnormalities/ or exp Musculoskeletal Manipulations/ or exp Musculoskeletal Diseases/ osteopathic medicine/ or exp orthopedics/ or exp Rheumatology/ or exp Physical Medicine/ or exp Podiatry/ |
| Limits: English language Human 1970 to current | | |

Table 3. Inclusion and exclusion criteria applied to potentially relevant studies to determine suitability for systematic review purposes.

| | Inclusion criteria | Exclusion criteria |
|--|---|---|
| Population | Medical students Residents Physicians | Nurses Physiotherapists Other allied professionals |
| Intervention | Lectures Workshops Physician-led small group learning sessions SP teachers Patient educators Peer teachers Structured clinical interviews Teaching OSCEs Simulations Videos Textbook/print materials CAL Other structured teaching activities or materials | Clinical rotations Shadowing/mentoring Clinical experience Practice audits Feedback alone (unless provided in conjunction with another educational intervention) |
| Comparator | Any teaching method described under the inclusion criteria for <i>Intervention</i> section Any 'standard curriculum' | |
| Outcome (Based on modified Kirkpatrick's 1967 model of hierarchical outcomes) | As it relates to MSK physical examination: Change in attitudes/perceptions Confidence self-ratings Comfort self-ratings Change in knowledge Written exam scores Change in skills OSCE scores Observed assessment scores Change in behaviour Inclusion of skill in clinical practice Patient Outcomes | Learner reaction Satisfaction with teaching method Satisfaction with instructor Procedural skills outcomes such as injection and aspiration techniques |
| Study type | Comparative studies which provide primary data for any of the outcomes listed above, including the following designs: RCTs Non-randomized control trials Controlled before and after studies Interrupted time series English language (Morrison et al. 2009) | Studies reporting on needs assessments for MSK teaching Studies reporting the prevalence of MSK skills teaching Opinion papers Uncontrolled before and after studies Articles not in the English language |

variables in their design other than as a measure of baseline characteristics among participant groups.

Analysis

The included studies were found to be too heterogeneous in terms of design, interventions and outcome assessments to be combined for quantitative statistical analysis. As a result, the included studies were qualitatively described by intervention as these subgroups provided homogeneity that allowed for useful comparison of relative effectiveness. Each intervention was further subdivided by comparators and outcomes assessed according to Kirkpatrick levels to give greater context to the results (Table 4, available as supplemental material online at <http://informahealthcare.com/mte>). To give a sense of overall efficacy, each intervention was summarized by combining all comparators and outcomes assessed. The descriptive analysis was meant to bring clarity to studies identified by previously described inclusion and exclusion criteria, but was not in itself part of the screening or exclusion process for the primary studies. Evidence tables detailing study characteristics (including population, intervention,

comparison, outcomes and design), results and authors' conclusions are provided (Tables 4–6).

Results

Overview of included studies

Figure 1 presents a flow diagram of the study selection process. About 5089 studies were identified by electronic database searches and 354 studies were identified by reference and hand searches. Title and abstract screening identified 265 potentially relevant studies. Inclusion forms were applied with full text review of these 265 studies and this identified 24 studies that were relevant to our investigation. Of these, 12 were randomized controlled trials (RCTs), 4 were non-concurrent cohort studies and 8 were prospective cohort studies. Ten of the 24 studies were conducted in the USA, with the remainder based in the UK ($n=7$), Australia ($n=4$), Canada ($n=2$) and Switzerland ($n=1$). Eighteen of the 24 studies were concerned with undergraduate medical education, while 5 investigated residents ($n=3$) or both

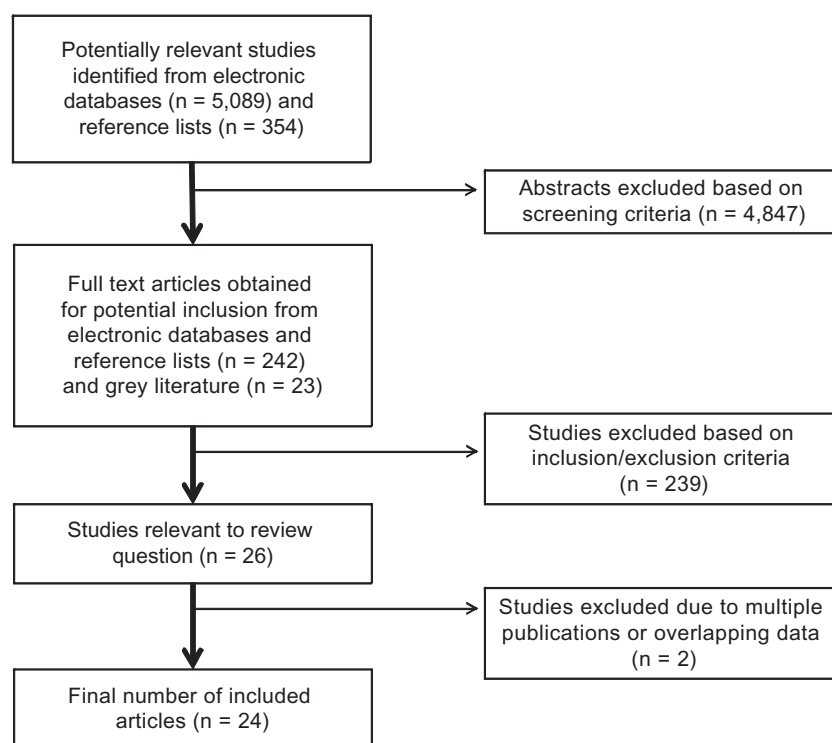


Figure 1. Flow diagram of included studies.

undergraduates and residents ($n=2$). Only one study's participants were practising physicians. Although participants in the majority of included studies included uni-professional medical trainees or physicians, the teachers and intervention facilitators represented a variety of professions, including medicine, physiotherapy and the lay public.

Several included studies assessed more than one level of Kirkpatrick learning outcomes. Within all the included studies, 1 of 24 assessed a change in behaviour, 21 of 24 assessed change in skill, 5 of 24 assessed change in knowledge and 4 of 24 studies assessed a change in attitudes or perceptions. None of the studies evaluated patient outcomes. In total, over 2500 participants were involved in the included studies.

Methodological quality and risk of bias of included studies

Quality and Risk of Bias tools were applied to all 24 included studies and none were excluded subsequently on the basis of their quality assessment scores. The methodological quality of the studies varied; however, several weaknesses were common to particular designs. Over half of the RCTs did not describe their randomization process ($n=7$) and the majority ($n=10$) did not attempt or describe the process of allocation concealment. Five trials did not attempt to blind participants to their intervention groups and the outcomes being measured, and an additional five trials did not adequately blind participants. Moreover, two trials did not adequately blind all outcome assessors, and two others did not state whether evaluators were blinded to participant intervention. In half of the trials ($n=6$), outcome data were either incomplete or inadequately addressed. One trial was found to be at risk of

selective outcome reporting. Five trials did not present any baseline characteristics of the groups being compared, and two trials described only the age and sex of their participants. Finally, one trial used a cluster randomization process and inappropriately analysed data on an individual basis.

A limitation common to the majority of both prospective and non-concurrent cohorts was an unclear or absent description of whether outcome assessors were blinded to intervention groups ($n=9$). In addition, only 4 of 12 studies took into account the comparability of cohorts and controlled for participants' level of relevant education (including year of residency and completion of related electives) or learning style. Moreover, in three of the cohort studies, the exposed group was a select group of student volunteers, and in three cases, the derivation of the non-exposed cohort was inadequately described or derived from a different source. Three cohort studies did not clearly present data for participant follow-up and another provided no statement regarding extent of follow-up. One cohort study did not have adequate follow-up of participants, as its loss-to-follow-up rate was greater than 10% of study participants and there was an incomplete description of those lost.

Characteristics of included studies

Table 4 (available as supplemental material online at <http://informahealthcare.com/mte>) provides a summary of the interventions, comparators, outcomes measured and main findings of all included studies. The outcomes of interest varied among studies; however, 15 of 24 studies utilized Objective Structured Clinical Examination (OSCE) scores as a primary measure of students' skill in performing the musculoskeletal PE.

Tables 5 and 6 detail the characteristics and results of all included studies. The following provides a narrative overview of the results grouped according to intervention.

Patient educators

Nine studies involving 492 participants investigated the effectiveness of patient educators as teachers compared to a standard curriculum ($n=3$), a video ($n=1$) or sessions led by a general practitioner ($n=1$) or expert in rheumatology ($n=4$). Of these, three were observational studies and the remainder RCTs. Three studies compared patient educators to a standard curriculum: one RCT (27 participants) and one observational study (19 participants) found significant differences in terms of skill favouring the patient educator, while another observational study (unclear number of participants) found no difference. Four studies compared patient educators to experts in rheumatology. All studies assessed changes in skill and found very different results with one RCT (23 participants) favouring the patient educator, a cluster RCT (62 participants) favouring the rheumatology expert and two RCTs (130 participants) finding no difference. One observational study (37 participants) compared patient educators to sessions led by a general practitioner and showed a change in skills favouring the patient educators. Finally, one RCT (181 participants) compared patient educators to a video: results for skill, knowledge and confidence favoured the patient educator. Overall, eight of nine studies showed patient educators to be no different ($n=3$) or better than ($n=5$) their comparators across a variety of outcomes (Table 4, available as supplemental material online at <http://informahealthcare.com/mte>).

Interactive, small group learning

Five studies involving 499 participants compared interactive small group sessions or a curriculum with emphasis on this teaching strategy to didactic teaching styles and traditional curricula. Four of these studies were observational and one was an RCT. The majority (including the RCT) favoured the small group teaching style, with findings of improved skill, knowledge and confidence. Only one observational study (145 participants) showed discrepant results, favouring the traditional curriculum over the small group, interactive curriculum in terms of skill acquisition. This study had a considerably unequal distribution of teaching time; students in the traditional curriculum received 20 h of clinical teaching, whereas those in the small groups-oriented program received only 3 h of instruction. In comparable studies, the teaching time was equal, lengthier in the small groups curricula or was not noted (See Table 5, available as supplemental material online at <http://informahealthcare.com/mte>). The differences in instruction time may be responsible for these conflicting results.

Computer-assisted learning

Three RCTs and one observational study involving 529 participants evaluated the effectiveness of CAL. Two studies compared CAL to traditional curricula: one cluster RCT (354 participants) found a difference in skill favouring CAL but

found no difference in confidence, while one observational study (197 participants) found no difference in knowledge. One study compared CAL to bedside teaching (27 participants) and found no difference in skill acquisition. Another study (61 participants) compared CAL to a textbook and found a significant difference favouring CAL in terms of change in skill. The same study also compared CAL to experts in rheumatology, and found no difference.

Other interventions

The interventions, comparators and outcomes of the remaining six included studies varied considerably. Peer-assisted learning was assessed in two studies involving 310 participants. One observational study (64 participants) found no difference in skill change for peer-assisted learning compared to instruction by a physiotherapist. This same study and another observational study (310 participants) compared peer-assisted learning to the standard curriculum and found differences favouring peer-assisted learning in terms of skill change. One cluster RCT (264 participants) compared instruction by a general practitioner versus a physiotherapist and found no difference in skills between groups. Likewise, one RCT (144 participants) compared standardized physical exam associates (SPEAs) versus physician faculty and found no difference in skills. One observational study (11 participants) examined the use of reminder sheets pre-patient interview versus standard curriculum and found that reminders significantly changed behaviour. Finally, one observational study compared a new GALS teaching approach to a traditional curriculum and found changes in skill (264 participants) and confidence (218 participants) favouring GALS.

Discussion

All stages of medical training were represented in this review, although majority of studies (18 of 24) focused on undergraduate medical education. A variety of teaching interventions were evaluated among the included studies. The findings of this review resonate overall with larger adult learning theory as represented by Spencer's progressive learning philosophy. In this theoretical framework, teachers strive to engage and guide students through learning experiences that are educative, stimulating and yet purposeful and contextually relevant (Spencer 1998).

Patient educators

For example, in the case of patient educators, learners encounter a highly contextually relevant experience that is likely to represent one of their first independent patient encounters. Jha et al. (2009) also note that the use of patients as teachers was advantageous for students as it allowed for immediate feedback, and facilitated a non-threatening learning environment. Further, they note that students consider the method to be 'stimulating and satisfying', a finding that was echoed by the authors of several studies included in our review of MSK clinical skills teaching techniques (Hendry et al. 1999; Haq et al. 2006). The current review found the use of

patient educators to be an effective teaching method in terms of skill, knowledge and confidence improvement. Eight of the nine patient educator-related studies found no difference or superiority of patient educators to their comparators, which included experts in rheumatology, general practitioners, video and the standard curriculum.

Our findings regarding the relative effectiveness of patient educators are consistent with a 2009 review on this subject (Jha et al. 2009). They found that the use of patient educators resulted in 'improved proficiency in clinical skills' in eight of nine studies concerned with musculoskeletal, cardiopulmonary and general chronic disease physical examination and history taking. Their review also found that only one study reported a negative impact (Humphrey-Murto et al. 2004). In that study, students taught by rheumatology faculty passed more OSCE stations and had significantly higher scores at two out of nine stations. Our review also identified this study as one of nine that favoured a comparator over patient educators for number of OSCE stations passed; however, for this trial's stated primary outcome of overall OSCE score, there was no significant difference between the two groups.

Standardized physical exam associates

In addition to patient educators, some institutions have explored other non-faculty dependent modes of education. One review of simulation in psychiatric education found both videotapes and live interaction with standardized patients (SPs) to be effective in teaching interviewing skills in clerkship and junior residency years of training (McNaughton et al. 2008). Our review identified one RCT investigating the use of SPEAs (which included some SPs as well as other community members), which found no differences in skill for students instructed by associates compared to physician faculty.

Small group interactive learning

The surprising paucity of literature evaluating large versus small group PE teaching may be due to the fact that most authors support Ericsson's (2004) theory that deliberate practice with specific feedback is critical to the mastery of skills. It is likely that most authors presume that small group settings are more likely than large group demonstrations to facilitate clinical skills learning and thus few studies have been performed. The findings of this review resonate with this learning principle in their support of small group clinical skills teaching. Four of five studies favoured a small group interactive teaching style for the instruction of clinical skills over a traditional, didactic form of teaching.

Computer-assisted learning

Where CAL is less contextually grounded than patient educator or small groups interactive teaching strategies, it still provides stimulating and self-directed learning opportunities in keeping with progressive adult learning theory, and the findings of this review suggest that it may be an effective method of teaching MSK clinical skills. However, a meaningful and comprehensive analysis of CAL was problematic, due to the heterogeneity of

CAL applications in the included studies. A review of CAL for medical education concluded that at the undergraduate level the gain of knowledge was variable among programs (Hammoud et al. 2006). A similar variety among studies was noted in the current review. Two of four studies found CAL to be better than its comparator for at least one outcome, while the remaining studies showed no difference. Our findings thus agree with previous reviews, and further suggest that CAL may be an effective means of promoting MSK clinical skills transfer. An additional review of web-based continuing medical education programs found them to be equivalent to traditional teaching methods in effecting knowledge change (Wutoh et al. 2004). Recent reviewers have further determined that CAL for continuing medical education effectively induces change in practice patterns lasting up to 12 months (Lam-Antoniades et al. 2009).

The authors commented that further research is required to elucidate which components of CAL are most effective in order to maximize their usage. A recent longitudinal study of a CAL program for an undergraduate medical course determined that the type of CAL used by students was related to gender, personality preference and learning style (McNulty et al. 2009). This finding coincides with previous research (Chumley-Jones et al. 2002; Cook 2005) and suggests that the most effective CAL programs will offer a variety of tools and teaching methods. In the future, such results may be applied in designing CAL interventions for teaching MSK clinical skills.

Limitations

By prospectively determining our search strategy and having two authors screen papers for inclusion, we minimized inclusion bias, and believe our review to be inclusive of all relevant studies. However, the review is limited by the methodological quality of included studies. Both RCTs and observational studies were at a high risk of bias due to inadequate blinding of participants and/or outcome assessors. In addition, many included trials did not present complete outcome data, or did so in an unclear manner. Either of these flaws may result in an overestimation of an intervention's effects. Similarly, few RCTs presented adequate baseline data to allow the authors to confirm balance between the groups and few cohorts accounted for differences in learning style or level of education.

Another limitation relates to the fact that only three studies provided power calculations. As a result, for most studies, it is not possible to determine if observations of no difference between the interventions being compared represents actual equivalence or simply points to insufficient statistical power (i.e. Type II errors). We recommend that future publications in this field include power calculations to allow for more meaningful conclusions to be drawn.

The review is also limited by weaknesses inherent to the field of investigation, many of which have been previously discussed. As with any evaluation of teaching strategies, one cannot entirely control for variables such as teaching skill, student-teacher relationships and confounding exposures that have occurred in the learning cohorts. Schmidt et al. (1987) have thoroughly outlined the difficulty in controlling for

extraneous variables that may affect outcomes, particularly in studies that extend over a period of time. Authors have also detailed the struggle of identifying and isolating the relative contributions of different curricular components that may affect outcomes (Schmidt et al. 1987, 1996; Tamblyn et al. 2005). As there is a lack of 'gold standard teaching modalities' against which interventions may be compared and as most studies did not provide validation analyses of their outcome measures, it is difficult to draw conclusions regarding the absolute effectiveness of the strategies presented rather than their relative merit. Additionally, existing outcomes and measurement tools may ineffectively assess important areas of physician competence (Berkson 1993; Vernon & Blake 1993; Distlehorst et al. 2005).

For example, none of the included studies evaluated patient outcomes and thus we are unable to conclude whether one teaching method is superior in terms of this important outcome. One study assessed the efficacy of using reminder sheets prior to commencing a relevant patient interview; the reminder sheets prompted house officers to apply MSK history taking and PE recommendations they had previously been taught (Mazzuca et al. 1993). Investigators found that trainees asked appropriate questions and performed specific MSK PE manoeuvres on suitable patients with more frequency when they received a reminder sheet. This study demonstrated a change in behaviour in a clinical context and the authors noted that 'at least 65% of arthritis patients with chronic joint pain received thorough physical examinations to rule out disorders other than arthritis', suggesting that as a result, patients may have received an improved quality of care.

Finally, the heterogeneity of populations, designs, interventions, comparators and outcomes measured prohibits the deduction of a single most efficient teaching method. For the same reasons, the findings cannot be generalized to medical trainees of all levels or differing education settings.

Advantages of non-traditional teaching methods

Many authors of studies included in this review commented that patient educators and CAL are resources that could be applied to teach MSK clinical skills while minimizing educational costs in terms of physical space and faculty tutor time (Hasle et al. 1994; Vivekananda-Schmidt et al. 2005; Avers et al. 2009). These interventions are relatively inexpensive and have been found to be no different or better in terms of confidence, knowledge and skill outcomes. Vivekananda-Schmidt et al. (2005) investigated the efficacy of a 'Virtual Rheumatology CD', and found no difference in confidence and superior OSCE scores for students using the CD, versus those exposed to the traditional curriculum only. The cost of the program was \$22 045, which arose primarily from CD production. Given the current technology, this is much less of an issue, as demonstrated by Avers et al. (2009), whose research group created a similar rheumatology web-based resource at minimal cost. This tool was found to be equivalent to a teaching session by an expert in rheumatology and superior to a textbook. Hasle et al. (1994) analysed the costs and benefits of using SPs to help teach clinical exam skills, as opposed to faculty alone. They determined that it was less

costly to train and employ SPs to teach the PE, and also found no difference in students' performance on OSCEs. Similarly, patient educators who often teach on a voluntary basis are also a cost-effective use of resources.

Conclusions

This review is the first of its kind to consider broad MSK clinical skills teaching in medicine and provides supportive evidence for the use of interventions that maximize engagement and realistic context for medical trainees and physicians. Several instructional strategies were found to be an effective means of teaching MSK clinical skills with most studies supporting patient educators, interactive small group learning and CAL. Furthermore, our findings highlight the need for future studies to elucidate how and why these interventions are effective, and provide guidance regarding study design and quality for investigators in the field of MSK clinical education.

As curricula evolve, interest in the use of alternate instructional methods is increasing, and many may be more efficient and cost-effective than traditional strategies. Our findings provide support for curriculum planners who are already implementing the strategies reviewed with limited access to evidence behind them, and may also direct teaching methodology choices, as educators strive to maximize teaching efficiency with limited instruction time.

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References and supplemental material

The references for this article, along with Tables 4 and 5, accompany the online version of *Medical Teacher* at <http://informahealthcare.com/mte>. Table 6, a summary of the main findings of the review, is also available online.