Background. Evidence-based practice (EBP) is an important paradigm in health care. Physical therapists report lack of knowledge and time constraints as barriers to EBP.

Objective. The purpose of this technical report is to illustrate how Medical Subject Headings (MeSH), a controlled vocabulary thesaurus of indexing terms, is used to efficiently search MEDLINE, the largest component of PubMed. Using clinical questions, this report illustrates how search terms common to physical therapist practice do or do not map to appropriate MeSH terms. A PubMed search strategy that takes advantage of text words and MeSH terms is provided.

Results. A search of 139 terms and 13 acronyms was conducted to determine whether they appropriately mapped to a MeSH term. The search results were categorized into 1 of 5 outcomes. Nearly half (66/139) of the search terms mapped to an appropriate MeSH term (outcome 1). When a search term did not appropriately map to a MeSH term, it was entered into the MeSH database to search for an appropriate MeSH term. Twenty-one appropriate MeSH terms were found (outcomes 2 and 4), and there were 52 search terms for which an appropriate MeSH term was not found (outcomes 3 and 5). Nearly half of the acronyms did not map to an appropriate MeSH term, and an appropriate MeSH term was not found in the database.

Limitations. The results are based on a limited number of search terms and acronyms.

Conclusions. Understanding how search terms map to MeSH terms and using the PubMed search strategy can enable physical therapists to take full advantage of available MeSH terms and should result in more-efficient and better-informed searches.
Evidence-based practice (EBP) has become an important paradigm in health care. The American Physical Therapy Association Vision Statement for Physical Therapy 2020 states, in part, that "physical therapists... will render evidence-based services throughout the continuum of care." Five steps comprise the process of EBP: (1) asking a clinical question, (2) acquiring the information related to the clinical question, (3) appraising the information, (4) applying the information, and (5) assessing the EBP process. Asking, acquiring, appraising, and applying require that clinicians gain particular skill sets to efficiently execute the EBP process.

Although texts and guides are available to learn about EBP, clinicians frequently report barriers, such as lack of knowledge and time constraints, to practicing in an evidence-based manner. Jette et al surveyed physical therapists and found that younger therapists and those licensed less than 5 years were more likely to report formal training in search strategies and familiarity with online databases than older physical therapists and physical therapists licensed for a longer period. Schreiber et al conducted case studies with 5 school-based physical therapists. Although the number of years in practice and training in EBP varied, 2 of the 5 physical therapists reported difficulty with searching. In a survey of Australian physical therapists, Iles and Davidson reported that lack of skills related to searching was a barrier to EBP. Across multiple studies, lack of time was consistently reported as a barrier. Assisting clinicians with searching more efficiently may eliminate knowledge barriers and time constraints.

Physical therapists can choose from several databases when searching for evidence to answer their clinical questions. Some databases such as Hooked on Evidence and Physiotherapy Evidence Database (PEDro) are focused on physical therapy. Others such as the Cumulative Index of Nursing and Allied Health Literature (CINAHL) and PubMed have a wider scope.

Hooked on Evidence is made up of extractions, a type of synopsis of original studies. Included in the extract are measures of treatment effectiveness such as standardized mean difference and number needed to treat. Extracts in the database are from randomized controlled trials (RCTs), clinical trials, cohort studies, case-control studies, case reports, trials with a single-subject experimental design, and cross-sectional studies. Access to Hooked on Evidence is limited to members of the American Physical Therapy Association (APTA). On May 04, 2011, the database had 6,444 extractions of articles.

PEDro is freely available and includes bibliographic citations to RCTs, systematic reviews, and clinical practice guidelines. Although a synopsis is not provided, the methods of RCTs are reviewed and scored using the PEDro scale. On May 04, 2011 PEDro had 19,026 records.

CINAHL, a subscription database, is available in different versions. Members of APTA can access the version CINAHL with Full Text via the link to Open Door: APTA’s Portal to Evidence-Based Practice. CINAHL with Full Text focuses on nursing and health care professions journals, begins indexing journals from 1981, and includes more than 3,000 journals, of which 610 are full-text journals. CINAHL with Full Text has more than 2 million records.

PubMed, which is freely available, is a search system for health information and has more than 20 million citations. The largest component of PubMed is MEDLINE, a free online database of biomedical journal citations and abstracts. MEDLINE includes citations to many different types of studies, including, but not limited to, RCTs, clinical trials, cohort studies, case-control studies, case reports, trials with a single-subject experimental design, cross-sectional studies, qualitative studies, systematic reviews, and clinical guidelines.

Physical therapists also may choose to use a search engine such as Google Scholar to search for answers to their clinical questions. Google Scholar retrieves information from a wide range of sources such as journals, conference papers, academic books, and dissertations. Because of the wide coverage, Google Scholar often will retrieve more citations than a dedicated database such as PubMed. However, a larger retrieval set is not necessarily better because it may be difficult to find relevant information among potentially irrelevant search results. Google Scholar relies on text word searching rather than a vocabulary indexing system. Text word searching may miss relevant citations when the search terms are not in the citation. The ranking of results in Google Scholar is determined by the number of times the links have been clicked and the number of times the articles have been cited. The practical outcome is that older citations may appear higher in the retrieval set than newer citations. Google Scholar, which indexes articles, not journals, does not provide a list of available journal titles.
Using MeSH to Enhance PubMed Search Strategies

making it difficult to know what might be missed in a search.²¹ Although the wide coverage of Google Scholar is beneficial, the limits related to text word searching, ranking of results, and unavailability of a list of journal titles make Google Scholar better suited as an adjunct to a search.²¹

Because of differences in coverage and focus, a particular database may be more or less useful in a given situation. For example, Moseley et al.²² using a set of RCTs, reported that PEDro indexed a higher proportion of the RCTs (279/281; 99%) than PubMed (256/281, 91%), CINAHL (170/281, 60%), or Hooked on Evidence (112/281, 40%). However, because physical therapists may have clinical questions related to diagnosis and prognosis and because some clinical questions are best studied using qualitative research, we believe physical therapists should be familiar with searching MEDLINE for answers to clinical questions. As previously noted, PubMed, which is freely available, offers easy access to MEDLINE.

The size and scope of MEDLINE require a system for indexing citations. The Medical Subject Headings (MeSH) database provides such a system. Specifically, MeSH is a controlled vocabulary thesaurus of indexing terms arranged in a hierarchy; MeSH terms lower in the hierarchy are more specific or narrower than those higher in the hierarchy.²³ Indexing MEDLINE citations with MeSH terms provides a consistent way to find citations, even when authors use different terms for the same concept.²⁴ For example, when authors of articles describe the same concept with different terms (eg, “cerebral vascular accident,” “stroke”), the citations are indexed with the same MeSH term (eg “stroke”), eliminating the need to search using all possible synonyms for the same concept. The MeSH database, first published in 1960, is continually updated and revised annually.²⁵ Furthermore, physical therapists can submit suggestions for MeSH terms. Changes to the MeSH database are reported on the MeSH Web site.²⁶

Physical therapists using PubMed can enter words or phrases directly into the PubMed query box.¹⁷ This approach takes advantage of automatic term mapping (ATM), a process in which PubMed searches for a match between the search term and the MeSH term, journal title, and author.²⁷ Depending upon the search terms entered, an appropriate match to a MeSH term may or may not be found. When a search term maps to a MeSH term, the MeSH term and more specific or narrower MeSH terms in the MeSH hierarchy also are searched.²⁷ Regardless of the MeSH match, the search term also is searched as a text word in fields of the MEDLINE record (ie, title, abstract).²⁷

Using MeSH has been shown to improve the efficiency of searches, that is, retrieving fewer irrelevant citations. Jenuwine and Floyd²⁸ compared text word and MeSH searching and found that text word searches were more sensitive (retrieved a greater number of relevant citations) and that MeSH searching was more specific (retrieved fewer irrelevant citations). Text word searching may have been more sensitive because some concepts important to the search used by Jenuwine and Floyd,²⁸ such as the concept “healthy,” were not represented in the MeSH database. Searches that have high sensitivity and high specificity are ideal. Haynes et al²⁹ also found that search strategies designed to find methodologically sound studies in adult medicine retrieved a higher proportion of relevant studies when they included MeSH terms and text words. For the text word portion of the search to be effective, variations in spelling (ie, British, American), synonyms for the search concept (eg, “aquatic,” “pool”), and plurals³⁰ must be entered into the search query box. Recently, Rana et al³¹ validated a search assessment tool. Appropriate use of MeSH terms was identified as 1 of the 5 critical elements in the development of an effective MEDLINE search,³¹ further highlighting the need to understand MeSH.

A strength of PubMed is the ATM process. As noted above, search terms are automatically examined for a possible match to a MeSH term. Physical therapists who know very little about MeSH terms may find relevant search results because of the ATM process. However, by becoming familiar with MeSH terms for their clinical practice area, physical therapists can harness the powerful MeSH indexing feature of MEDLINE and improve the efficiency of their searches.

The purposes of this technical report are: (1) to illustrate how search terms and acronyms common to physical therapist practice may or may not map appropriately to a MeSH term and (2) to recommend a PubMed search strategy that takes advantage of text word searching and MeSH terms.

Method
We began by generating a preliminary list of possible search terms common to physical therapist practice to search in PubMed. Two published sources were used: the Clinical Research Agenda for Physical Therapy³² and the Research Agenda for Geriatric Rehabilitation.³³ To provide context for the search results, we developed hypothetical clinical questions using the PICO (Patient [or Population], Intervention, Comparison, Outcome) format.³⁴ Clinical
questions included search terms representing diseases and disorders (eg, spina bifida, low back pain), interventions (eg, exercise, mobilization), and outcomes (eg, function, reduction of pain) that would likely be searched across a variety of areas in physical therapy (eg, orthopedics, pediatrics). We also selected search terms that we thought were pertinent based on our teaching and clinical knowledge. Because a physical therapist may use search phrases as well as individual words, we considered a phrase a search term. An example of a hypothetical clinical question and associated search terms was: “Do strengthening exercises reduce pain in patients with patellofemoral pain?” Examples of search terms associated with this clinical question include: “strengthening exercises,” “eccentric exercises,” “exercise,” “strengthen,” “strengthening,” “patellofemoral,” and “pain.” The final set of search terms was not meant to be exhaustive. The list of search terms is presented in the eAppendix (available at ptjournal. apta.org).

Search terms were entered into the query box on the main (home) PubMed search page and then searched. The Search Details page was checked to determine how PubMed processed the search.27 Specifically, we were interested in determining how or whether the search term was translated or mapped to a MeSH term. We used the clinical question to provide a context for judging whether a search term mapped to an appropriate MeSH term, that is, whether the MeSH term represented the concept being searched. Although a phrase could map to a MeSH term, it was not necessary for each word of the phrase to map to a MeSH term for the mapping to MeSH to be appropriate. If a search term automatically mapped to a MeSH term, the definition of the MeSH term was reviewed to determine whether the MeSH term conceptually related to the clinical question. We also examined the MeSH hierarchy to determine whether appropriate broader or narrower MeSH terms existed. Both the definition of the MeSH term and the MeSH hierarchy were accessed through the MeSH database. When a search term did not automatically map to a MeSH term, we entered the search term into the query box of the MeSH database to determine whether a MeSH term conceptually related to the clinical question was available. If so, we again examined the MeSH hierarchy to determine whether appropriate broader or narrower MeSH terms existed.

We also developed a list of acronyms common to physical therapist practice to search in PubMed. The process we followed was similar to the process used with the search terms. However, rather than determine appropriateness of the MeSH term based on a clinical question, we determined the appropriateness of the MeSH term based on the meaning of the acronym. The list of acronyms is presented in the eAppendix.

For both search terms and acronyms, we categorized the search results into 1 of 5 possible outcomes:

- Outcome 1: The search term mapped to an appropriate MeSH term.
- Outcome 2: The search term mapped to a MeSH term that was not appropriate or to a journal title; however, we found an appropriate MeSH term in the MeSH database.
- Outcome 3: The search term mapped to a MeSH term that was not appropriate or to a journal title, and we did not find an appropriate MeSH term in the MeSH database.
- Outcome 4: The search term did not map to a MeSH term or journal title, but we found an appropriate MeSH term in the MeSH database.
- Outcome 5: The search term did not map to a MeSH term or journal title, and we did not find an appropriate MeSH term in the MeSH database.

Rather than calculating reliability, we simultaneously reviewed the MeSH definition relative to the clinical question and used consensus to determine the outcome category for a search term.

## Results

We entered 139 search terms and 13 acronyms into the PubMed query box to determine whether they mapped to a MeSH term. The results of the ATM process were categorized into 1 of the 5 outcomes. Nearly half of the search terms mapped to an appropriate MeSH term (outcome 1: 66/139, 47%). For outcomes 2 and 3, the search term mapped to a MeSH term that was not appropriate or to a journal title. After we searched the MeSH database, an appropriate MeSH term was found 4% of the time (outcome 2: 6/139), but was not found 12% of the time (outcome 3: 17/139). For outcomes 4 and 5, the search term did not map to a MeSH term or journal title. After we searched the MeSH database, an appropriate MeSH term was found 11% of the time (outcome 4: 15/139), but was not found 25% of the time (outcome 5: 35/139). Only 2 acronyms mapped to an appropriate MeSH term (outcome 1: 2/13). Several of the acronyms (outcome 5: 5/13) did not map to a MeSH term or journal title, and we did not find an appropriate MeSH term in the MeSH database. Figure 1 illustrates the findings across the search terms and acronyms for all 5 outcomes. The Table includes selected examples of search terms for outcomes 1 to 5.

## Discussion

Search results using search terms related to clinical questions posed by the authors were categorized into 1...
of 5 outcomes. In 66 searches, the search terms mapped to appropriate MeSH terms (outcome 1). In 21 searches, after querying the MeSH database, we found appropriate MeSH terms for the search terms entered (outcomes 2 and 4). In these instances, if a physical therapist did not query the MeSH database, he or she would be relying on text word searching, despite the existence of an appropriate MeSH term. This type of searching is uninformed and inefficient and may result in suboptimal retrieval. For example, the search term “falls” did not map to a MeSH term; however, a MeSH term, “accidental falls,” is in the MeSH database. Depending on the clinical question, failure to use the MeSH term may result in missing a citation that could lead to a change in patient treatment. This failure is akin to not taking a blood pressure measurement when a blood pressure finding could lead to a change in patient treatment. In 52 searches, the search term did not map to an appropriate MeSH term, and when the search term was entered into the MeSH database, an appropriate MeSH term was not found (outcomes 3 and 5). In this instance, text word searching is the only option, and physical therapists must use variations in spelling, synonyms, and plurals to adequately represent the search concept to increase the likelihood of finding relevant citations.

Our findings based on the acronyms we chose to search are limited; few mapped to an appropriate MeSH term. This finding agrees with previous literature. Searching for a concept only using the acronym to represent the concept is not recommended. If a physical therapist chooses to use an acronym, he or she should search using both the acronym and its full spelling.

Physical therapists are expected to practice in an evidence-based manner. Finding answers to clinical questions is one step in the EBP process. Because physical therapists frequently report a lack of knowledge and time constraints as barriers to practicing in an evidence-based manner, we propose a PubMed search strategy (Fig. 2) designed to take advantage of MeSH terms. Although we have not tested this approach empirically, based on our results and previous literature, we believe physical therapists will develop more-efficient and better-informed searches using the suggested PubMed search strategy.
### Table.
Examples of How Search Terms Mapped, Organized by Outcomes

<table>
<thead>
<tr>
<th>Outcome 1: The search term mapped to an appropriate Medical Subject Headings (MeSH) term.</th>
<th>Search Term</th>
<th>MeSH Term/Journal Title</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical therapy</td>
<td>Physical therapy modalities (MeSH)</td>
<td>The MeSH definition states: Therapeutic modalities frequently used in physical therapy (specialty) by physical therapists or physiotherapists to promote, maintain, or restore the physical and physiological well-being of an individual.</td>
<td></td>
</tr>
<tr>
<td>Therapeutic exercise</td>
<td>Exercise therapy (MeSH)</td>
<td>The MeSH definition states: A regimen or plan of physical activities designed and prescribed for specific therapeutic goals. Its purpose is to restore normal musculoskeletal function or to reduce pain caused by diseases or injuries.</td>
<td></td>
</tr>
</tbody>
</table>

| Outcome 2: The search term mapped to a MeSH term that was not appropriate or to a journal title; however, an appropriate MeSH term was found in the MeSH database. | Balance | Balance (journal) | The search term mapped to a journal name. However, the MeSH term “postural balance” was in the MeSH database and is defined as: A posture in which an ideal body mass distribution is achieved. Postural balance provides the body carriage stability and conditions for normal functions in stationary position or in movement, such as sitting, standing, or walking. |
| Education | Educational status (MeSH) Education (MeSH) | The search term mapped to MeSH terms related to the formal course of study or educational level of an individual. However, the MeSH term “exercise movement techniques” was in the MeSH database and is defined as: Methods or programs of physical activities that can be used to promote, maintain, or restore the physical and physiological well-being of an individual. |

| Outcome 3: The search term mapped to a MeSH term that was not appropriate or to a journal title, and an appropriate MeSH term was not found in the MeSH database. | Function | Physiology (MeSH) | The MeSH definition states: The biological science concerned with the life-supporting properties, functions, and processes of living organisms or their parts. |
| Labral tear | Tear (MeSH) | The search term “labral” did not map to a MeSH term. The search term “tear” translated to the MeSH term “tear.” The MeSH definition states: The fluid secreted by the lacrimal glands. This fluid moistens the conjunctiva and cornea. |

| Outcome 4: The search term did not map to a MeSH term or journal title, but an appropriate MeSH term was found in the MeSH database. | Strengthening | None | The MeSH term “resistance training” was found in the MeSH database and is defined as: A type of strength-building exercise program that requires the body muscle to exert a force against some form of resistance, such as weight, stretch bands, water, or immovable objects. Resistance exercise is a combination of static and dynamic contractions involving shortening and lengthening of skeletal muscles. |
| Stretching | None | The MeSH term “muscle stretching exercises” was found in the MeSH database and is defined as: Exercises that stretch the muscle fibers with the aim to increase muscle-tendon flexibility, improve range of motion or musculoskeletal function, and prevent injuries. There are various types of stretching techniques, including active, passive (relaxed), static, dynamic (gentle), ballistic (forced), isometric, and others. |

| Outcome 5: The search term did not map to a MeSH term or journal title, and an appropriate MeSH term was not found in the MeSH database. | Exam | None | Use text words to capture variations of the search term (eg, exam OR examination). |
| Impairment | None | Use text words capture variations of concept for example (eg, impairment OR limitation). |
A fundamental step of the search strategy is to check the Search Details page. Checking the Search Details page allows the physical therapist to determine whether the search terms did or did not map to a MeSH term. To determine whether the MeSH term is appropriate, that is, conceptually related to the clinical question, the physical therapist should check the definition of the MeSH term. This definition check is easily done by searching for the MeSH term in the MeSH database. For example, the search term “pain” mapped to the MeSH term “pain,” which is defined in the MeSH database as an unpleasant sensation induced by noxious stimuli that are detected by nerve endings of nociceptive neurons. The search term “mobilization” mapped to the MeSH term “metabolism,” which is defined in the MeSH database as chemical reactions within cells. “Metabolism” is an inappropriate MeSH term if the clinical question is related to mobilization as a treatment technique. Examining the MeSH term in the MeSH database also allows the physical therapist to determine whether there are broader or narrower MeSH terms in the MeSH hierarchy that are related to the clinical question. As physical therapists become more familiar with the MeSH terms related to their area of clinical practice, their need to review the definition of MeSH terms decreases.

In addition to MeSH, PubMed has several features that enhance physical therapists’ ability to find information related to clinical questions. Two of these features are Clinical Queries and My NCBI (National Center for Biotechnology Information). Clinical Queries, a search option available in PubMed, is designed to find citations of studies of applied clinical research, systematic reviews, and medical genetics.17 Using MeSH along with Clinical Queries can make searches more efficient by finding studies that are considered high levels of evidence, such as a well-conducted RCT. Another feature of PubMed is My NCBI, which also can enhance physical therapists’ searching efficiency. My NCBI allows users to save robust searches with appropriate MeSH terms. The searches are automatically run at set times chosen by the user, and the search results are sent to the user’s e-mail.17 A full description of these features is available in the PubMed tutorial.37

Limitations
The search terms used in this technical report were related to the clinical questions posed, were limited in number, and are not representative of all search terms. Thus, the actual percentages reported for each
outcome may vary for a different set of search terms. However, this technical report illustrates the usefulness of checking the Search Details page to determine how or whether the search terms mapped to MeSH terms and the usefulness of checking the MeSH database to determine whether the MeSH term is appropriate or a more appropriate MeSH term is available. Failure to take these steps may result in the physical therapist using an uninformed search strategy, relying on the ATM process, which may or may not be mapping appropriately, and on text words, which may or may not be comprehensive.

The MeSH database is dynamic, and new MeSH terms are routinely added to the database. The extent to which future changes in the MeSH database would influence these results is unknown. However, we believe the recommended PubMed search strategy is appropriate regardless of the clinical question posed and MeSH database updates.

Conclusion
MEDLINE, a free online database of biomedical journal citations and abstracts, can be searched using PubMed. Because of the size of MEDLINE, a system of indexing terms, MeSH terms, was developed as a consistent way to find citations, even when authors use different search terms for the same concept. This technical report illustrates the usefulness of understanding whether search terms map to appropriate MeSH terms. Using the PubMed search strategy will enable physical therapists to take full advantage of available MeSH terms and should result in more-efficient and better-informed searches by addressing commonly cited barriers to practicing in an evidence-based manner: lack of knowledge and time constraints.

Dr Richter provided concept/idea/project design. Both authors provided writing, data collection and analysis, and consultation (including review of manuscript before submission).

A poster presentation of this work was given at the Combined Sections Meeting of the American Physical Therapy Association; February 9–12, 2011; New Orleans, Louisiana.


References
Using MeSH to Enhance PubMed Search Strategies


