A 7-year-old boy with cerebral palsy who enjoyed fishing, hiking, and playing baseball was referred to our outpatient clinic for reexamination. He reported that he was having new difficulties playing baseball in a specialized community league. These difficulties included maintaining an upright stance while batting and getting to the bases quickly enough after hitting the ball. He was born at 30 weeks gestational age, and his ability to reach developmental milestones has always been delayed. His pediatrician diagnosed him with spastic diplegic cerebral palsy at 18 months corrected age.

Since he was 18 months old, he was a regular patient of another physical therapist at our outpatient clinic, visiting once a week. The boy originally worked on developmental sequencing, transitions, and gait, and he consistently met his goals, including his goal of ambulating in the home and community. Physical therapy visits were cut back to once every other week to continue working on increasing range of motion (ROM), muscle strengthening, and gait, and to remedy new problems as they arose. Therapy eventually was put on hold because he became more involved in community programs and he consistently missed appointments. He recently began attending physical therapy again because of his difficulties playing baseball.

Our patient ambulated all distances wearing bilateral solid ankle-foot orthoses (AFOs) and using Loftstrand crutches. Active and passive ROM was normal for all 4 extremities, with the exception of decreased hip extension (0°–10°), knee extension (-15°), and ankle dorsiflexion (0°–10°) bilaterally, with active ROM more limited than passive ROM. Manual muscle tests of the bilateral lower extremities revealed weakness in his hip extensors, hip flexors, hip abductors, knee extensors, and ankle dorsiflexors, with muscle grades of 2+/5, 3/5, 2/5, 3/5 and 2+/5 respectively. He ambulated with a crouch gait pattern and reduced step length bilaterally at approximately 50% of normal velocity.

**Clinical question:** What are the effects, if any, of lower-extremity strength training on gait in children with cerebral palsy?

The purpose of “Evidence in Practice” is to illustrate the literature search process to obtain evidence that can guide clinical decision making. This article is not a case report. The examination, evaluation, and intervention sections are purposely abbreviated.

Wendy S Pippenger was a student in the DPT program at the University of Illinois at Chicago, Chicago, Ill, at the time this article was written.

David A Scalzitti, PT, MS, OCS, is Associate Director, Research Services, American Physical Therapy Association, Alexandria, Va.
The goals of the patient and his parents were to develop a more normalized gait pattern in order to help him participate in his community baseball league. He wanted to be able to maintain a more upright stance while batting and to increase the speed of his gait.

We were aware of a recent article by Fowler et al. that investigated the effect of strengthening exercises on hypertonicity (also known as spasticity) in children with diplegic cerebral palsy. This study had demonstrated that a single session of exercise training of the quadriceps femoris muscle did not increase spasticity as measured by the pendulum test. Because this study did not investigate the effects of an exercise program on gait, we decided to perform a literature search for the most current evidence on the effects of lower-extremity strength training on the gait of a child with spastic cerebral palsy.

**Database used for search:** PubMed

We began our search using PubMed (www.ncbi.nlm.nih.gov/PubMed) because it is a free resource, it is available to the general public, and it is easily accessible via the Internet from a computer in our clinic. We selected PubMed because it includes a number of medical and rehabilitation journals that are likely to include articles on this topic. The search was performed on May 4, 2004.

**Keywords used in the search:** “cerebral palsy” AND “strength training”

We selected “cerebral palsy” and “strength training” as keywords for our initial search because these terms represent both the condition and intervention in our clinical question. We typed “cerebral palsy” AND “strength training” into the query box. Each term was placed in quotation marks in order to search for articles where these words appear as a unit. The conjunction “AND” was used and capitalized to instruct PubMed to only select articles that included both “cerebral palsy” and “strength training” as keywords. The search identified 10 citations (Fig. 1).

![Figure 1. Citations retrieved from the PubMed search using the keywords “cerebral palsy” AND “strength training”](image)

Although other keywords similar to “strength training” exist, these terms either appeared to be too broad or too specific for our query. For example, substituting “exercise” resulted in more than 200 citations because the results also included articles on other forms of exercise, such as stretching and aerobic activities. Alternately, replacing “strength training” with “resistance training” retrieved only 2 citations.

As we read the list of titles, we quickly singled out a recent systematic review by Dodd and colleagues (Fig. 1: citation 5) on the topic of strength training for people with cerebral palsy. A systematic review appeared to be an ideal place to start because the authors likely used specific methods to search and summarize the literature and may have reviewed many of the other studies on this topic that we retrieved from our search. A systematic review is believed to represent a higher level of evidence because it summarizes several studies and uses methods...

OBJECTIVE: To determine whether strength training is beneficial for people with cerebral palsy (CP). DATA SOURCES: We used electronic databases to find trials conducted from 1966 through 2000; key words used in our search were cerebral palsy combined with exercise, strength, and physical training. We supplemented this search with citation tracking. STUDY SELECTION: To be selected for detailed review, reports found in the initial search were assessed by 2 independent reviewers and had to meet the following criteria: (1) population (people with CP), (2) intervention (strength training or a progressive resistance exercise program), and (3) outcomes (changes in strength, activity, or participation). Of 989 articles initially identified, 23 were selected for detailed review.

DATA EXTRACTION: Empirical studies were rated for methodologic rigor with the PEDro Scale, and studies with a PEDro score of less than 3 were excluded. Review articles were evaluated for quality with the National Health Service Centre for Reviews and Dissemination form. DATA SYNTHESIS: Of the 23 selected articles, 11 studies (10 empirical, 1 review) met the criteria for quality and were included. Only 1 randomized controlled trial was identified. With respect to impairment, 8 of the 10 empirical studies reported strength increases as a result of a strength-training program, with effect sizes ranging from d equal to 1.16 (95% confidence interval, 1.1-2.21) to d equal to 5.27 (95% CI, 4.69-5.05). Two studies reported improvements in activity, and 1 study reported improvement in self-perception. No negative effects, such as reduced range of motion or spasticity, were reported. There was insufficient evidence from which to draw conclusions about the effects of environmental and personal contextual factors.

CONCLUSIONS: The trials suggest that training can increase strength and may improve motor activity in people with CP without adverse effects. More rigorous studies are needed that have a greater focus on changes in activity and participation and that consider contextual factors.

We knew that our initial judgments about the relevance of this article would be limited to the information that appeared in the abstract because we would not be able to go to the medical library to access the full text of the article until we had completed patient care for the day. According to this abstract, studies published between the years 1966 and 2000 that met the authors’ criteria were selected for the systematic review. We noted that articles published since 2000 would not appear in this review and that we would need to access these more recent articles for additional, more current information. According to the abstract, 11 studies met the authors’ criteria for inclusion in the systematic review, which led us to suspect that this review included many of the studies from our PubMed search that were published before 2000.

From this systematic review, it appeared that most of the studies reported a beneficial effect of strength training on impairments that we assumed are related to muscle performance. We would not be sure of this, however, until we read the full text of the article. We were also pleased to see that the abstract noted no negative effects on impairments as a result of strength training. According to the abstract, 2 studies reported improved activity; however, it was unclear from the abstract whether the outcome measures for activity were related to gait. It also was unclear whether the other 9 articles in the systematic review reported no change in outcomes related to activity or whether they measured these outcomes.

We were encouraged that this systematic review included evidence that may help with our clinical decision, but we realized that we would have to wait until the end of the day when we could get to the library for additional information. Another option to access the full text of the article would be to obtain the article electronically from the publisher for a fee. The PubMed record for this article provides a link to the journal publisher’s Web site, which we clicked on for more information. We learned we could access the article electronically for $30, but decided we would wait until we could get to the library.

Although we were encouraged that a systematic review had been published on this topic, we were interested in seeing whether any articles more recent than this review provided additional information. Because the PubMed search results are listed in reverse chronological order, it appeared that some more recent articles on this topic exist. To find out more about these articles, we could have continued reading the abstracts in PubMed; however, we would still be limited to information that is contained in the abstracts. Therefore, we decided to access another database that could provide us with more information regarding the studies beyond that found in their abstracts.

- **Database used for additional search:** Hooked on Evidence

We decided we would access Hooked on Evidence, the American Physical Therapy Association’s (APTA) online database of studies on the effectiveness of physical therapy interventions. We chose Hooked on Evidence because it provides extractions that summarize the evidence from the original...
research articles in a standardized format. The extraction provides more information on the study design, methods, interventions, and outcomes than that typically found in an abstract of an article.

Hooked on Evidence is a work in progress where contributors complete an extraction of a primary research article online. As of the date of our search, 1,350 extractions were available from the database. According to the FAQ page of the Hooked on Evidence Web site, all primary studies that include a physical therapy intervention are eligible for inclusion in the database. The types of study designs entered into Hooked on Evidence include randomized clinical trials, nonrandomized clinical trials, cohort studies, case-control studies, single-subject experimental designs, and case reports and case series reports. Access to Hooked on Evidence is a membership benefit of APTA and also is available to nonmembers by subscription. It is available through APTA’s Web site (www.apta.org/hookedonevidence/index.cfm). Because any study of a physical therapy intervention that is indexed by a biomedical indexing database (including PubMed, CINAHL, and PsychInfo) is eligible for inclusion in Hooked on Evidence, and because of the additional information provided in the extraction compared with the abstract in the other databases, we decided to use this resource. The searches were conducted on May 4, 2004.

We decided to use the same keywords that we had used in our PubMed search in Hooked on Evidence. After logging onto the Hooked on Evidence database using the first author’s (WSP) APTA membership number, we typed “cerebral palsy” AND “strength training” into the query box on the main search screen and hit the Search button (Fig. 2). Five citations resulted from this search (Fig. 3).

Hooked on Evidence also allows the user to search using an ICD-9 code for the condition. Using a reference list, which is accessed by a link ICD-9 located below the query box on the main search page (Fig. 2), we found that the ICD-9 code for cerebral palsy is 343. We returned to the search screen and entered (“cerebral palsy” OR 343) AND “strength training” to repeat the search and see whether the database had any additional extractions on this topic. The ICD-9 code, 343, was combined with the operator “OR,” and parentheses were placed around this combination so that the search would find all articles indexed according to either term. The terms
in the parentheses were then combined with the term “strength training” using “AND” so that the extractions identified included both combinations of terms. This search resulted in the same 5 citations.

The user also can use an asterisk as a truncation symbol to search for words with alternate endings. Because we believed some articles may also be indexed with alternative keywords such as “strength” or “strengthening,” we performed one additional search using the asterisk. Returning to the search screen, we typed (‘cerebral palsy’ OR 343) AND strength*, which returned the same 5 citations and 7 additional citations. Most of these additional articles, however, appeared to be related to the measurement of muscle force (ie, strength) and not to strength training. In addition, others were published before 2000 and likely were included in the systematic review of Dodd et al. Therefore, we were fairly confident that we had identified all of the recent citations in Hooked on Evidence related to our clinical question.

Selection of articles for review: We were pleased that Hooked on Evidence contained extractions of all of the articles related to strength training and cerebral palsy in children that were identified in the PubMed search (Fig. 1: citations 1, 2, 4) and published subsequent to the systematic review by Dodd et al. The search in Hooked on Evidence also identified an additional recent article from Pediatric Physical Therapy (Fig. 3: citation 2). This citation was not located by our PubMed search because this journal is not indexed by MEDLINE. This article was eligible for inclusion in Hooked on Evidence because it was indexed by the Cumulative Index to Nursing and Allied Health Literature (CINAHL), fulfilling one of the eligibility requirements listed on the FAQ page of Hooked on Evidence. The search results in Hooked on Evidence contained one article that was older than the systematic review (Fig. 3: citation 1); therefore, we assumed it would likely have been included in the review. A number of other older articles that we obtained from the PubMed search (Fig. 1: citations 6, 8–10) did not appear in the search of Hooked on Evidence. Hooked on Evidence is a work in progress, and, although its goal is to contain all of the studies related to physical therapy interventions, the database does not contain every study yet.

The results of a search in Hooked on Evidence are not presented in chronological order; instead, they are ordered according to the frequency in which the search terms appear in the extraction (APTA Webmaster, personal communication, May 4, 2004). We decided that we should look at the extractions for citations 2 through 5 (Fig. 3) to see how they relate to our clinical question. We decided not to look at citation 1, because it was older than the systematic review by Dodd et al. The abstracts of each of the articles we examined are reproduced below.*

* Editor’s note: Because of space limitations, Physical Therapy cannot reprint each extraction. Instead, the abstracts will be reprinted. For a sample extraction, see Figure 4.
To access the extraction of the article by Eagleton et al from *Pediatric Physical Therapy*, we clicked on the hyperlink located within the citation. The database showed a screen with standard fields of information extracted from the original article (Fig. 4). These fields included information on the study design, purpose, methods, types of interventions, and outcomes. Clicking on a button located on the upper right, titled Enhanced Results, provides more detailed information (when available) regarding the study, including the number of subjects, inclusion and exclusion criteria, and calculations of treatment effect size for various outcomes of the study.

The study by Eagleton et al was a single-subject experimental design. According to the Enhanced Results screen, 13 children with cerebral palsy between 12 and 20 years of age who could ambulate at least 45 m (150 ft) underwent a strength training program. The program was performed in a community setting 3 times a week for 4 weeks in a group setting. The program was effective in increasing the distance walked in 3 minutes, gait velocity, step length, and cadence with gait also improved for the 8 children who were ambulatory. Walking speed, stride length, and cadence improved with training. The children with cerebral palsy in this study were between 4 and 8 years of age—an age similar to our patient. According to the extraction of this single-subject experimental design, the 8 children who were ambulatory were assigned to one treatment group that participated in a group circuit training program for 1-hour sessions twice a week for 4 weeks. Pretraining and posttraining data for 22 outcomes related to muscle performance and gait were summarized in the extraction. Force production of the lower-extremity muscle groups and performance on functional strength tests, such as lateral step-ups, improved with training. Walking speed, stride length, and cadence with gait also improved for the 8 chil-

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1. The effects of strength training on gait in adolescents with cerebral palsy

Eagleton M, Iams A, McDowell J, Morrison R, Evans CL

**Target Condition:**
343 - Infantile cerebral palsy

**Element of Patient/Client Management Model:** Intervention

**Practice Pattern:** Neuromuscular - Pattern C: Impaired Motor Function and Sensory Integrity Associated With Nonprogressive Disorders of the Central Nervous System - Congenital Origin or Acquired in Infancy or Childhood

**Design Type:** Single-Subject Experimental Design

**Study Population:** Children (4-12 years), Adolescents (13-17 years), Adults (18-64 years)

**Population Location:** Outpatient / ambulatory care, Health and wellness

**Number of subjects:** 13

**Clinical characteristics of study participants:** Subjects displayed various presentations of cerebral palsy.

**Authors Stated Purpose:** To examine the effects of strength training on gait in adolescents with cerebral palsy and to provide an assessment of subjects' preference for exercising in a community fitness setting.

**Interventions:**
- Patient / Client Related Instruction
- Therapeutic Exercise
  - Flexibility
  - Muscle strength, power, and endurance training

**Study Outcomes:**
- Impairments
  - Neuromuscular
  - gait
- Patient / Client satisfaction
  - other

**Results By Outcome:**
Outcome 1 - Continuous

**Authors Conclusions:** This study did not report group means therefore unable to provide any data in the results by outcome section. However, the article did include pre and post test data for each subject. The results of this pre-test post-test design suggest that a six-week strengthening program was effective in increasing the distance walked in three minutes, gait velocity, step length, and cadence of the group and resulted in an overall decrease in the energy expenditure index. All subjects in this study reported a preference for exercising in a community fitness atmosphere as opposed to exercising during routine physical therapy appointments. Confirming these findings with a larger sample size and objective measures to determine any difference in trunk and lower extremity strength may offer a new evidence-based method of intervention for adolescents with CP.

*Figure 4.* Extraction of the Eagleton et al article in Hooked on Evidence.
The purpose of this clinical trial was to explore the positive and negative outcomes of a home-based training program for young people with cerebral palsy. Eleven children between the ages of 8 and 18 years who could ambulate independently participated in a 6-week resistance training program in their home that targeted the lower-extremity muscles. The outcomes of this study were the perceptions of the children and their parents about this form of training, perceptions that appeared to be very positive. Because this study was qualitative in nature, the results presented by Hooked on Evidence were mainly descriptive and not as detailed as the other extractions we read. We noted this information and planned to obtain the full text of the article for further details and to confirm the information in the extraction.

The next extraction we accessed was of an article written by some of the same authors as the previous article.

This randomized controlled trial also utilized a 6-week home training program and included 21 participants who were in a training group or control group. The outcomes and conclusion section of this extraction summarized that muscle training can improve strength in children with cerebral palsy and that beneficial effects on gait were observed. The extraction also summarized information on 10 outcomes related to muscle performance and functional mobility. Because the extraction includes some of the data for both the treatment group and control group, the database calculated measures of treatment effect size for these outcomes. For continuous outcomes, such as muscle performance and gait velocity, the absolute mean dif-
ference and the standardized mean difference are calculated using data provided in the original article. The Hooked on Evidence FAQ page provides the calculations and references for these measures.

For each outcome in this extraction, a graph displayed the standardized mean difference (Fig. 5). Because the value of the standardized mean difference was to the left of 0, it suggested that the end (posttraining) mean for this outcome, strength of the knee extensors, was better for the training group than for the control group. Because the 95% confidence interval for this outcome included 0, however, we could not conclude with 95% certainty that there was a difference between the 2 groups. We also looked at the baseline (pretraining) and end (posttraining) data provided for this outcome. From this data, it appeared that the increase in knee extensor strength was greater for the training group, but differences were apparent in the baseline data. We intended to confirm this information when accessing the full text of the article.

The extractions in Hooked on Evidence indicated that 4 to 6 weeks of strength training for improves force production of the muscles exercised and appears to improve clinical measures of gait in children with cerebral palsy.

**Review of full-text articles:** After finishing patient care for the day, we visited our medical library to read the full text of these articles to check the accuracy of this information and to see if the articles provided any additional insights.

**Eagleton et al:** This study provided the pretraining and posttraining measures for each of the 7 subjects for step length, cadence, gait velocity, and distance walked in 3 minutes. Of the 7 subjects, 5 demonstrated increased step length, 4 improved the cadence of gait, 6 demonstrated improvement in gait velocity, and 6 walked further distances in the timed 3-minute walk. The change in posttraining distance ambulated during the test compared with pretraining was between 0 m and more than 100 m.

**Blundell et al:** The full-text version of this article confirmed the information in the Hooked on Evidence extraction. In addition, the article provided information on measurements obtained 8 weeks after the cessation of training. The format of Hooked on Evidence encourages the reporting of preintervention and immediate postintervention results. The information from the article suggested that gains in muscle performance and the measures of gait were maintained during the 8-week follow-up period.

**Dodd et al:** The information in the full text of this article was consistent with the information in the Hooked on Evidence extraction. According to a comparison of the baseline characteristics performed by the authors, the children in the training group had greater physical disabilities as measured by the Gross Motor Function Measure than the children in the control group. The differences between the groups may explain why the children in the training group had greater gains in muscle force than the control group and why the measures of treatment effect size in Hooked on Evidence (which used only the posttraining data) did not reflect this difference. The full text of the article supported the idea that the training group had greater gains in muscle force than the control group and the idea that there was only a trend of greater improvement for the outcomes related to walking. The article also stated that the children who trained were able to maintain the improvements in muscle force and gait 12 weeks after the end of the 6-week training period.

**McBurney et al:** The full text of this article confirmed that the participants in this qualitative analysis were members of the same training group in the randomized controlled trial by the same group of authors. The full-text article also confirmed
the results summarized in the Hooked on Evidence extraction regarding the positive perceptions of the training program by the study participants.

**Dodd et al (from the PubMed search):** Finally, we accessed the full text of the systematic review by Dodd et al that we retrieved from our PubMed search. The paper confirmed what we originally read in the PubMed abstract. The authors used explicit methods to identify and include appropriate studies. The studies favored improvement in muscle force with training and only 2 studies demonstrated no change in muscle force. The studies that measured other impairments found that range of motion and spasticity were not adversely affected by strength training programs. Only 4 of the articles included in the systematic review measured changes in activity. The measures for activity in these studies included walking speed and the Gross Motor Function Measure total score and the score for section E. Calculated effect sizes for changes in these measures were smaller than the effect for the muscle force measures. There were no negative effects of strength training reported in these studies. The 11 trials covered in this systematic review included the 5 studies published before 2000 that were retrieved in our initial PubMed search.

**Clinical decision:** Based on the current evidence we identified, we believed that, in children with cerebral palsy, strength training can improve muscle performance and also can improve gait to a lesser extent. According to the articles we found, there were no adverse effects (eg, increased spasticity, decreased function) from implementing a strength training program. We therefore decided to suggest a strength training protocol to our patient to help him meet his goals.

We decided to base this program on the exercises in the randomized controlled trial by Dodd et al because it demonstrated the benefits of a strengthening program on outcomes associated with gait and because the exercises could be performed at home. Because of our patient’s busy schedule and his frequently missed appointments in the past, we suggested a home-based program that he could do once per day for 3 days a week. We planned to have him come into the clinic to learn the program, and then, after 2 weeks, reassess his ability to carry out the program with only his parents’ assistance. From there, we would continue to monitor his progress on a monthly basis for the first 3 months and adapt the program as needed.

We plan to recommend the exercises used in the study by Dodd et al, which included bilateral heel raises, bilateral half squats, and step-ups. Additional resistance would be provided by adding weight to a backpack. An initial training weight would be determined to allow the patient to complete 3 sets of 8 to 10 repetitions of each exercise. We would provide verbal and written instruction in progression of the program.

In order to monitor and assess progress, we would measure force production of the major lower-extremity muscle groups through dynamometry. Although we had initially used manual muscle testing, the studies we reviewed used handheld dynamometers to quantify muscle performance. We, therefore, planned to use a dynamometer to obtain baseline measurements of the major muscle groups of the lower extremity during his next physical therapy visit. We also would measure his gait velocity to obtain a baseline measure and would reassess this at the monthly follow-up visits.

Although our 7-year-old patient is slightly younger than the participants in the study by Dodd et al, we thought that this clinical difference was not important enough to expect different results from a strength training program. In addition, the other studies we reviewed found that children of similar ages to our patient can benefit from resistance exercise. The training programs we reviewed had durations up to 12 weeks; therefore, the benefits of longer training periods are not known at this time. At the end of 3 months, based on the results of the follow-up examinations and achievement of his goals, we planned to determine, with our patient and his family, whether they needed or wanted the program to be continued or modified.

**References**