

# Review of Selected Physical Therapy Interventions for School Age Children with Disabilities

Prepared for the Center on Personnel Studies in Special Education

by

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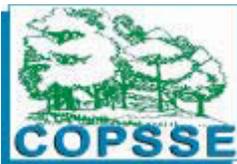
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COPSSE research is focused on the preparation of special education professionals and its impact on beginning teacher quality and student outcomes. Our research is intended to inform scholars and policymakers about advantages and disadvantages of preparation alternatives and the effective use of public funds in addressing personnel shortages.

In addition to our authors and reviewers, many individuals and organizations have contributed substantially to our efforts, including Drs. Erling Boe of the University of Pennsylvania and Elaine Carlson of WESTAT. We also have benefited greatly from collaboration with the National Clearinghouse for the Professions in Special Education, the Policymakers Partnership, and their parent organizations, the Council for Exceptional Children and the National Association of State Directors of Special Education.

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## INTRODUCTION

PL 108-446, the Individuals with Disabilities Education Improvement Act of 2004 [IDEA] (2004) requires special education and related services to be “based on peer-reviewed research to the extent practicable.” (§300.320(a)(4)). This requirement, not included in previous versions of the law, is consistent with the current strong emphasis on evidence-based practice in physical therapy and the American Physical Therapy Association’s [APTA] *Guide to Physical Therapist Practice*, which provides a framework for describing and implementing physical therapy. However, much of the research on physical therapy interventions for children with disabilities is weak and conducted in non-educational environments.

This paper reports on physical therapy procedural interventions with enough research available to have been the topic of one or more systematic reviews. The interventions covered include: adapted seating for children with cerebral palsy [CP]; conductive education; constraint-induced movement therapy; lower extremity casting, orthoses, and splints for children with neurological disorders; neurodevelopmental treatment; partial body weight supported treadmill training; passive stretching to improve range of motion [ROM]; strengthening for children with CP; and weight bearing interventions for children with CP. The paper also provides recommendations for application to physical therapy school-based practice and future research.

Congress intended for PL 108-446 (IDEA, 2004) to help children with disabilities “achieve to high standards” – by promoting accountability for results, enhancing parental involvement, and using proven practices and materials. Physical therapy as a related service supports a child’s academic, developmental, and functional goals as determined by the child’s family, the child if appropriate, and a team of professionals. The team outlines the child’s goals in an Individualized Education Program [IEP], with the ultimate aim of preparing the student for further education, employment, and independent living (IDEA, 2004; 34 CFR §300.1). Local educational agencies [LEAs] must provide physical therapy when a student requires physical therapy to benefit from special education.

A widely disseminated definition of evidence-based practice is the “integration of best research evidence with our clinical expertise and our patient’s unique values and circumstances” (Straus, Richardson, Glasziou, & Haynes, 2005, p. 1). This definition is more broad based and encompassing, not relying on peer-reviewed research alone. The best research evidence should be valid and relevant. As new evidence becomes available, previously accepted evaluation measures and interventions must be replaced. Clinical expertise develops with advancing clinical skills and experiences with children with disabilities. Parent and child values are the “unique preferences, concerns and expectations” (p. 1) that they bring to the situation. Physical therapists must integrate all these elements—research, expertise, and family/child factors—for evidence-based decision making.

APTA’s *Guide* describes intervention as:

the purposeful and skilled interaction of the physical therapist with the patient/client and, if appropriate, with other individuals involved in care of the patient/client, using various PT methods and techniques to produce changes in the condition that are consistent with the diagnosis and prognosis. (p. 43)

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Therapists make judgments regarding intervention based on evidence and the timely monitoring of the child’s responses and progress in achieving the anticipated goals. According to the *Guide*, intervention should include three important components: (a) coordination, communication, and documentation; (b) child/family-related instruction; and (c) procedural interventions.

**Table 1. Factors that Influence the Complexity, Frequency, and Duration of Physical Therapy Intervention and the Decision-Making Process**

accessibility and availability of resources
adherence to the intervention program
anatomical and physiological changes related to growth and development
caregiver consistency or expertise
chronicity or severity of the current condition
cognitive status
comorbidities, complications, or secondary impairments
concurrent medical, surgical, and therapeutic interventions
decline in functional independence
level of physical function
living environment
multisite or multisystem involvement
nutritional status
overall health status
premorbid conditions
probability of prolonged impairment, functional limitations, or disability
psychosocial and socioeconomic factors
psychomotor abilities
social support
stability of condition

(APTA, 2001, p.47)

*Coordination* involves the organization and management of services with all parties working together to ensure that the child and family “receive appropriate, comprehensive, efficient, and effective quality of care” (APTA, 2001, p. 47) from initiation of services to the end of services. Coordination might involve arranging for equipment, assisting in eliminating architectural barriers, arranging with teachers for the best time and place to observe a child’s classroom performance, and scheduling parent/teacher meetings. *Communication* includes written and verbal correspondence to convey information to the child, family, and other approved parties. *Documentation* is written information such as the evaluation report, progress notes and progress reporting, plan of care, summary letters to physicians, and information provided to Medicaid or other agencies that might pay for school-based services. *Child and family-related instruction* and instruction for others who spend time with the child (such as physical therapy assistants, teachers, and aides) usually are important elements of physical therapy intervention for children. The family and teachers frequently are responsible for assisting the child to carry out or practice many intervention activities. Proper instruction is necessary for the safety and protection of the child and the service provider. *Procedural interventions* occur when the physical therapist “selects, applies, or modifies... interventions... based on examination data, the evaluation, the diagnosis and the prognosis, and the anticipated goals and expected outcomes” (APTA, 2001, p. 47). **Table 1** lists factors that the *Guide* describes as important in the decision-making process, including decisions about the type and intensity of intervention. Community support, family

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desires and degree of participation, LEA policies, the child's desire to participate, and available research evidence also influence decisions about goals and choice of interventions.

This paper focuses on the peer-reviewed research on procedural interventions that physical therapists commonly use when working with children with disabilities (3-21 years) in schools. We report on interventions with enough research to have published systematic reviews, research using "explicit methods to systematically search, critically appraise, and synthesize the world literature on a specific issue. Its goal is to minimize both bias and random error" (Straus et al., 2005, pp. 147-148). Many common physical therapy interventions are not well researched; thus, published data is insufficient to support a systematic review. Systematic reviews, including meta-analyses that combine the results of studies quantitatively, are the most powerful and useful evidence available to support interventions (Straus et al.). The purposes of this paper are to identify: (a) effective physical therapy procedural interventions that lead to positive outcomes for children (3-21 years) with disabilities in schools; and (b) gaps in the evidence and areas requiring further research.

## METHODS

Common physical therapy interventions were identified by reviewing procedural interventions in the *Guide to Physical Therapist Practice* (APTA, 2001), the Iowa AEA Physical Therapy Consensus on Peer-Reviewed Intervention II (2005), and pediatric physical therapy textbooks. Based on the review of those resources, we searched for systematic reviews related to the following areas of procedural interventions: assistive technology; conductive education [CE]; constraint-induced movement therapy [CIT]; fitness, aerobic capacity, and endurance; function/goal-directed therapy; motor learning; neurodevelopmental treatment [NDT]; orthoses and casts; treadmill training; passive ROM and stretching; positioning; postural control; power mobility; strengthening; walking aids; and weight bearing. The databases searched included the Cochrane Database of Systematic Reviews, CINAHL, ERIC, MEDLINE, PsycINFO, PEDro, and APTA'S *Hooked on Evidence*. The search terms used are listed in **Table 2**.

**Table 2. Search Terms Used (alone and/or in combination)**

aerobic capacity	orthotic devices
adaptation	physical therapy
assistive technology	position
bone density	positioning
cerebral palsy	posture
child	postural control
conductive education	power mobility
constraint induced movement therapy	power wheelchair
contracture	range of motion
disabled children	research
endurance	school
equipment	seating
equipment design	self-help devices
exercise	splints
fitness	standing
function/goal directed therapy	strengthening
function	stretching
locomotion	systematic review
motor learning	treadmill training
motor skills	treatment outcome
movement	walking aids
neurodevelopmental treatment	weight bearing
orthoses	wheelchair

We included all the systematic reviews that met the following criteria:

- published in a peer-reviewed source
- focused on procedural physical therapy interventions with children aged 3-21 years with disabilities. The interventions could take place in any environment (limiting the review to studies completed in schools would have severely restricted the research available for review)
- published in English.

Each of the identified systematic reviews used a grading system to evaluate the research. Many guidelines and grading systems have evolved over the past few decades for use in systematic reviews of articles reporting intervention research. The most well-established system to grade the quality of research is that of Sackett, Rosenberg, Gray, Hayes, and Richardson (1996) (see **Table 3**).

**Table 3. Levels of Evidence for Interventions and Grades of Recommendations from Sackett**

Level of Evidence (Sackett, 1989)	Grade of Recommendation (Sackett, 1989)	Level of Evidence (Sackett et al., 2000)*	Type of Study (Sackett et al., 2000)*
Level I: Large randomized trials with clear-cut results (and low risk of error)	Grade A	1a 1b	Systematic reviews of randomized controlled trials (RCTs) Individual RCTs with narrow confidence interval
Level II: Small randomized trial with uncertain results (and moderate to high risk of error)	Grade B	2a 2b	Systematic reviews of cohort studies Individual cohort studies and low-quality RCTs
Level III: Nonrandomized, contemporaneous controls	Grade C	3a 3b	Systematic reviews of case-control studies Case-control studies
Level IV: Nonrandomized, historical controls	Grade C	4	Case series and poor-quality cohort and case-control studies
Level V: No controls, case-series only	Grade C	5	Expert opinion

\*pp. 173-177.

The scale has five levels, with Level I studies providing the strongest evidence based on randomized controlled trials and Level V the weakest evidence case studies. The American Academy of Cerebral Palsy and Developmental Medicine [AACPD] (2004) and Centre for Evidence Based Medicine [CEBM] (2001) have adopted similar scales for their systematic reviews. The AACPD scale was one of the first to include a grading system for single-subject design research (Butler & Darrach, 2001) (see **Table 4**).

The PEDro Scale, developed by the Centre for Evidence-Based Physiotherapy [CEBP] (2007), uses 11 criteria to evaluate research. Some systematic review authors used the PEDro Scale to evaluate the research and another scale to grade the level of evidence.

Each of the authors of this paper read and summarized the systematic reviews on approximately half of the procedural interventions. We agreed on the type of information to record for each review.

**Table 4. Levels of Evidence from the American Academy for Cerebral Palsy and Developmental Medicine**

Level	Non-empirical	Group Research	Outcomes Research	Single subject Research
I		Randomized controlled trial All or none case series		N-of-1 randomized controlled trial
II		Non-randomized controlled trial Prospective cohort study with concurrent control group	Analytic survey	ABABA design Alternating treatments Multiple baselines across participants
III		Case-control study Cohort study with historical control group		ABA design
IV		Before and after case series without control group		AB design
V	Descriptive case series/case reports Anecdotes Expert opinion Theories based on physiology, bench, or animal research Common sense/first principles			

(Butler & Darrach, 2001)

## RESULTS: SYSTEMATIC REVIEWS OF INTERVENTION PROCEDURES

Systematic reviews of the following interventions used with school age children with disabilities were found: (a) adapted seating for children with CP; (b) conductive education [CE]; (c) constraint-induced movement therapy [CIT]; (d) lower extremity casting, orthoses, and splints for children with neurological disorders; (e) neurodevelopmental treatment [NDT]; (f) partial body weight supported treadmill training [PBWSTT]; (g) passive stretching to improve ROM; (h) strengthening for children with CP; and (i) weight bearing interventions for children with CP. The results of these reviews are summarized below. Some research on the topics published subsequent to the reviews also is included.

### Adapted Seating for Children with Cerebral Palsy

Physical therapists often recommend and/or provide adaptive seating for children with CP, muscular dystrophy, and other conditions involving the neuromuscular and musculoskeletal systems.

**Table 5. Adapted Seating for Children with Cerebral Palsy**

Authors (Date)	Title	# Studies or Reviews (Year Range)	Main Conclusions
Roxborough (1995)	Review of the efficacy and effectiveness of adaptive seating for children with CP	8 studies (1982-1994)	Evidence supports effects of adaptive seating on some functions of children with CP, but stronger studies with functional outcome measures and studies of specific features of adaptive seating are needed.
Harris & Roxborough (2005)	Efficacy and effectiveness of PT in enhancing postural control in children with CP	6 studies (1990-2004)	Common features of studies that found an effect of seating on children's function were a slightly anteriorly tilted seat and stable pelvis, and thighs supported in a flexed and abducted position.

Proposed benefits of adaptive seating include improved postural control and alignment, improved hand and arm function, and prevention of deformities (McEwen & Hansen, 2006). Roxborough (1995) published a systematic review of research on the effects of adaptive seating on children with CP, as shown in **Table 5**. Adaptive seating was defined as “the custom prescription and application of sitting support devices based on therapeutic principles” (p. 17). The review included articles published between 1982 and 1994 meeting the following criteria: (a) participants included children with CP (birth–19 years); (b) adaptive seating was the independent variable; and (c) the study included an unsupported sitting group or condition without a comparison group. Each article was evaluated and the support for the intervention was graded according to the classification system (Sackett, 1989). The review included 8 studies. In 4 studies dependent variables were measured after providing adaptive seating only briefly in a controlled setting. In the other 4 studies children used adaptive seating for longer periods of

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time. One study was a single-subject design and the rest were group designs. Most of the studies used different dependent variables.

Three Grade A recommendations resulted from the systematic review, each from studies that examined the relatively immediate effects of adaptive seating in a controlled setting. These studies found positive effects of adaptive seating: (a) pulmonary function (Nwaobi & Smith, 1986); (b) active trunk extension (Miedaner, 1990); and (c) scores on the Bayley Mental Scale (Miedaner & Finuf, 1993). Grade B recommendations came from a thesis abstract (Gross, 1989) that reported no short-term effects of adaptive seating on reaching. The Grade C recommendations were from the 4 studies with weaker designs that examined effects of adaptive seating over longer periods of time. These studies showed adaptive seating to improve: (a) sitting posture (Hulme, Gallacher, Walsh, Niesen, & Waldron, 1987; (b) vocalization (Hulme, Bain, Hardin, McKinnon, & Waldron, 1989; and (c) oral motor eating skills (Hulme, Shaver, Archer, Mullette, & Eggert, 1987). The studies did not show an effect of adaptive seating on: (a) visual tracking (Hulme, Gallacher et al., 1987); (b) self-feeding (Hulme, Shaver, et al., 1987); and (c) drinking skills (Hulme, Shaver, et al., 1987). Roxborough (1995) concluded that studies with stronger designs and valid outcome measures are necessary for definitive answers about the effects of adaptive seating compared with unsupported sitting and to determine the specific features of adaptive seating required to achieve the desired outcomes.

In 2005 Harris and Roxborough published a systematic review to update and expand Roxborough's 1995 review. Studies of interventions for children with CP that were designed to improve postural control, identifying 6 studies that examined adaptive seating, were reviewed. They rated the studies as strong, moderate, or weak, and classified each according an early version of the AACPD Quality Assessment Scale (2004).

Recommendations were not graded as Roxborough (1995) did in the first systematic review; however, no Grade A recommendations would have been given using the same criteria. A grade B recommendation could be made for an effect of adaptive seating on postural control based on the 2 Level II studies (Reid, 1996; Washington, Dietz, White, & Schwartz, 2002). Five studies found improved postural control during short-duration interventions (Myhr & Von Wendt, 1991; Reid, 1996); intervention of moderate duration (Washington et al.); and at follow-ups of 3 years (Pope, Bowes, & Booth, 1994) and 5 years (Myhr, von Wendt, Norrlin, & Radell, 1995) follow-up. Common features of the adaptive seating in these studies were a slightly anteriorly tilted and stabilized pelvis and support of the thighs in a flexed and abducted position. Harris and Roxborough (2005) concluded that future studies of adaptive seating should not study postural control in isolation, but should examine the effects of adaptive seating on functional abilities and on the development of independent sitting.

The studies reviewed in Roxborough (1995) and Harris and Roxborough (2005) used a variety of seating devices and adaptations. Many reports, particularly the earlier ones, did not describe the devices and adaptations well enough for later researchers to replicate the equipment or replicate the process for making decisions about the type of seat and needed adaptations.

In summary, research indicates that adaptive seating can affect a child's function and postural control. A stable pelvis probably is important; and seating orientation is likely to make a difference for at least some children during certain tasks. This conclusion is consistent with a

review of evidence of effects of positioning on upper extremity function in children with CP (Stavness, 2006). The reviewed evidence supports an orientation in space of 0 to 15 degrees and a seat sloped forward 0 to 15 degrees, with the exact angle needing to be determined on an individual basis. Physical therapists should systematically evaluate children’s functioning in various positions in various positions and with adapted seating having various features to determine optimal positions for children who lack good postural control.

## Conductive Education (CE)

CE is a holistic approach to the development and education of children with neurological dysfunction, predominantly CP. Individuals trained to provide this intervention are called conductors. Although conductors are available in many parts of the world, an increasing trend, including in the U.S., is for physical therapists to provide the integrated gross motor portion of this curriculum. Parents frequently request this intervention for their children in school settings (Feinberg, Beyer, & Moses, 2002).

CE is not a therapy system but a system of education that aims to teach and motivate the child to function in society. Emphasis is placed on motivation, developing self-esteem, emotional and cognitive growth, and motor function. This school-based comprehensive program has gained popularity around the world, and a number of studies have been done in England and Australia. See the findings in **Table 6**.

**Table 6. Conductive Education**

<b>Authors (Date)</b>	<b>Title</b>	<b># Studies or Reviews (Year Range)</b>	<b>Main Conclusions</b>
Darrah, Watkins, Chen, & Bonin (2004)	Effects of Conductive Education intervention for children with a diagnosis of CP: An AACPD Evidence Report	15 studies (1972-2000)	The present literature base does not provide conclusive evidence either in support of or against CE as an intervention strategy. The limited number of studies and their weak quality makes it impossible for the literature alone to guide decision-making regarding CE.

A systematic review by Darrah, Watkins, Chen, and Bonin (2004) of 15 articles published between 1966 and 2001 found only 1 study with the highest level of evidence; 9 of the 15 studies were classified as Level III or IV. Most studies received weak ratings for control of threats to internal validity. These authors concluded that: “The present literature base does not provide conclusive evidence either in support of or against CE as an intervention strategy. The limited number of studies and their weak quality makes it impossible for the literature alone to guide decision-making regarding CE” (p. 202). The Darrah et al. review and a review by the Alberta Heritage Foundation for Medical Research (Ludwig, Leggett, & Harstall, 2000) suggest that CE is no more effective than “traditional educational and therapeutic intervention” and “there is no good scientific evidence to support the use of CE in place of other treatment programs for children with cerebral palsy” (p. ii). A study by Stiller, Marcoux, and Olson (2003), published after the systematic review, investigated the effects of intensive therapy (1 hour of individual

physical therapy, occupational therapy, speech therapy and group therapy per day), CE (6 hours/day), and special education (6 hours/day with therapy provided as indicated in the child's IEP) on the function of 19 children with CP. After a program of 5 days/week for 5 weeks, there were no statistical differences between groups; however, further analyses indicated statistically significant changes for the intensive therapy group on the Pediatric Evaluation of Disability Inventory (PEDI) self-care and social function scales and on the crawling and kneeling scales of the Gross Motor Function Measure (GMFM). The secondary findings of this non-randomized controlled trial study suggest that intensive therapy may be more effective for children with CP than CE or special education services; however, further investigation is clearly required.

In summary, the systematic reviews indicated that CE is as effective as traditional physical therapy when intensity of intervention is controlled. In general practice not involving research, CE has a higher level of intensity of intervention than traditional therapy. The lack of significant benefits of CE over traditional physical therapy when intensity is controlled for, coupled with the findings of Stiller et al. (2003), which suggest that intensive therapy is more effective for children with CP than CE or special education services, raises concerns about this intervention. Further investigation is clearly warranted.

## Constraint-Induced Movement Therapy (CIT)

CIT, previously referred to as forced use therapy, is a relatively new procedural intervention used by physical therapists. The protocols were first developed for adults who had had a stroke. The protocol involves the forced use of the impaired upper extremity while the other (non-impaired) extremity is constrained for most waking hours by a sling, mitt, or cast. See **Table 7**.

**Table 7. Constraint Induced Movement Therapy (CIT)**

Authors (Date)	Title	# Studies or Reviews (Year Range)	Main Conclusions
Charles & Gordon (2005)	A critical review of constraint-induced movement therapy and forced use in children with hemiplegia.	15 studies (1990-2005)	Studies suggest that CIT is a promising intervention for improving hand function in children with hemiplegia. However the data are limited and much more work must be done before this approach should be considered for general use in the clinic.

Many research studies have indicated the effectiveness of this intervention with adults post-stroke in improving upper extremity function (Levine & Page, 2004). Because of the success of CIT with adults, research has been undertaken in children with hemiplegic CP. A critical review by Charles and Gordon (2005) suggests that CIT appears to be a promising intervention for improving hand function in children with hemiplegia although “substantially more work must be performed before this approach can be advocated for general clinical use” (p. 245). More recently, a randomized crossover trial of CIT included 18 children with hemiplegia (Deluca, Echols, Law & Ramey, 2006). In the study, CIT produced significantly greater gains as

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measured on the Quality of Upper Extremity Skills Test and the Pediatric Motor Activity Log than conventional physical therapy and occupational therapy.

Several less intrusive protocols have been studied with the children with shorter wearing times of the splint or cast than used in CIT for adults (e.g., Charles & Gordon, 2006). No one protocol has been determined to be the most effective.

In summary, the CIT shows promise as an intervention for children with hemiplegic CP. CIT has not been studied directly in a school setting; however, it has been investigated with success in a day camp model (Bonnier, Eliasson, & Krumlinde-Sundholm, 2006). Further research is needed to know if CIT can be successfully implemented in a school setting, especially for children with hemiplegic CP who are usually fully integrated into the general education curriculum.

## Lower Extremity Casting, Orthoses, and Splints for Children with Neurological Disorders

Physical therapists often recommend casting, ankle-foot orthoses, and/or splints to maintain or improve lower extremity ROM, particularly ankle ROM; improve children's postural alignment in standing; and improve walking in children with disabilities. See **Table 8**.

**Table 8. Lower Extremity Casting, Orthoses, and Splints for Children with Neurological Disorders**

Authors (Date)	Title	# Studies or Reviews (Year Range)	Main Conclusions
Autti-Rämö, Suoranta, Antilla, Malmivaara, & Mäkelä (2006)	Effectiveness of upper and lower limb casting and orthoses in children with CP: An overview of review articles	4 systematic reviews (1995-2002)	Lower extremity casting does increase dorsiflexion ROM, but long-term and functional effects are not known. Different types of orthoses may have different benefits; orthoses designed to reduce muscle tone do not appear to improve functional skills; orthoses that limit plantarflexion have positive effect on equinus gait, but effects on other function is not known.

Autti-Rämö et al. (2006) studied systematic reviews on the effects of casting and orthoses in children with CP. They found 4 systematic reviews on lower extremity casting and orthoses that met their inclusion criteria and evaluated the quality of the reviews according to an 18-point scale based on criteria that Hoving et al. (2001) described. The criteria covered the quality of the search methods, selection methods, validity assessment, and synthesis. Each area had a maximum of 4 points except synthesis with a maximum of 6 points.

The highest quality review was by Morris (2002), with 8 points, followed by Vermeer and Bakx's (1990) 7-point review, and reviews by Hur (1995) and Teplicky, Law, and Russell (2002), each with 5 points. A major flaw identified by Autti-Rämö et al. (2006) was that

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authors of the systematic reviews did not consider the quality of the original studies in their conclusions.

Casting primarily is used to improve ankle ROM and ambulation. Based on the findings of the systematic reviews that studied effects of lower extremity casting, Autti-Rämö et al. (2006) concluded that casting does increase dorsiflexion ROM, but the clinical significance, including long-term effects and the influence on ambulation and other functions, is unknown.

Autti-Rämö et al. (2006) had difficulty drawing conclusions about the effects of lower extremity orthoses because of the variety of types of orthoses used in the original studies and the problems associated with trying to combine results when different types might not have the same effects. Orthoses that limit plantarflexion and improve equinus gait, for example, may make rising from the floor and other gross motor skills more difficult. Lack of appropriate comparisons also were a problem, such as comparing gait when walking with orthoses and walking barefoot, rather than comparing gait when wearing orthoses and supportive shoes. These authors concluded that different types of orthoses may have different benefits, such as on stride length, dorsiflexion, and balance, and that orthoses that help improve one aspect of gait or other function, such as rising from the floor or running, may interfere with another aspect of gait or function. They also concluded that orthosis designs intended to reduce muscle tone do not appear to improve functional skills and that orthoses that limit plantarflexion do have a positive effect on equinus gait, but any long-term meaningful effects are unknown.

In summary, the evidence on effectiveness of casting, orthoses, and splints for children with neurological disorders supports casting for increasing dorsiflexion ROM, but the influence on gait and function as well as long-term effects are unknown. The research on effects of orthoses and splints is inconclusive, except that designs intended to reduce muscle tone do not appear to improve functional skills and limiting plantarflexion does appear to reduce equinus gait.

## **Neurodevelopmental Treatment (NDT)**

NDT, developed by the Bobaths (1980), has been a commonly used approach for intervention of children with CP and other developmental disabilities. In NDT, the therapist uses a hands-on approach to facilitate normal movement patterns and to inhibit abnormal movement. The normal movement patterns are expected to carry over into daily functional activities. Two major systematic reviews have been done on the effects of NDT. See **Table 9**.

Butler and Darrah (2001) examined 21 studies specific to NDT for children with CP published between 1956 and 2000. Their publication had the approval of the AACPD Treatment Outcomes Committee Review Panel. Five studies were classified as Level I, the highest level of evidence, 10 as Level II, 2 as Level III, 4 as Level IV, and 1 as Level V. These authors reported inconsistent results of studies examining motor responses, contractures and deformity, and motor development. The results “did not confer any advantage to NDT over the alternative to which it was compared” (p. 789). The only exception was that ROM did improve immediately after the therapy session in 2 single-case studies (Embrey, Yates, & Mott, 1990; Laskas, Mullen, Nelson, & Willson-Broyles, 1985) and in 1 study after a 6-week treatment period (Herndon, Troup, Yngve, & Sullivan 1987). Additionally, no conclusive evidence existed that NDT produced

benefits in parent satisfaction, parent-child interactions, cognition, language, or social/emotional domains.

**Table 9. Neurodevelopmental Treatment (NDT)**

<b>Authors (Date)</b>	<b>Title</b>	<b># Studies or Reviews (Year Range)</b>	<b>Main Conclusions</b>
Butler & Darrah (2001)	Effects of neurodevelopmental treatment (NDT) for CP: An AACPDm evidence report.	17 studies (1973-2000)	The preponderance of results in the evidence table did not confer any advantage to NDT over the alternatives to which it was compared.
Brown & Burns (2001)	The efficacy of neurodevelopmental treatment in paediatrics: a systematic review	17 studies	Overall, the results regarding the efficacy of NDT were largely inconclusive since there were a similar number of published research studies supporting the benefit of NDT intervention (n=6) as compared with no benefit (n=9).

Brown and Burns (2001) also investigated the efficacy of NDT. They reviewed 16 studies using levels of evidence from Sackett. The primary study population was children with neurological impairments such as CP. Results of the analysis were inconclusive, both in support of and against NDT versus a control intervention. These authors concluded that the effectiveness of NDT with children has not been supported. A recent systematic review of 17 studies on the effect of early intervention on motor development of infants at high risk or with motor disorders, also showed that NDT and other programs “in which passive handling techniques have a prominent role, do not have a clear beneficial effect on motor development” (Blauw-Hospers & Hadders-Algra, 2005, p. 431). In summary, further research on the numerous specific elements of NDT and the many possible outcomes needs to be investigated because the effectiveness of NDT has not been supported through the published literature.

### **Partial Body Weight Supported Treadmill Training (PBWSTT)**

PBWSTT—a relatively new intervention approach that was first used with adults post-stroke and others with neurological impairments—is now being used with children with neurological disabilities. For this intervention, a child is suspended with varying amounts of support over a treadmill and is given manual assistance to walk on the moving treadmill. See **Table 10** for results.

LaForme Fiss and Effgen (2006) completed a systematic review of 15 studies published between 1966 and 2006 using the Sackett criteria. None of the studies was classified as a Level I, the highest level of evidence. The majority of the studies were classified as Levels III to V, indicating moderate to low levels of evidence, reflecting the high percentage of case reports examined in LaForme Fiss and Effgen’s review. The studies investigated children with a variety of diagnoses; the most common diagnosis reported was CP. Positive results were found with numerous standardized test scores, gait analysis parameters, and decreased age of onset of

walking. These authors concluded PBWSTT has potential to be an effective intervention for improving gait in children with delays and deviations in ambulation. A recent study by Begnoche and Pitetti (2007) on the effects of intensive physical therapy and PBWSTT for children with CP also suggests that these might be effective in improving motor skills of children with spastic CP.

**Table 10. Partial Body Weight Supported Treadmill Training (PBWSTT)**

<b>Authors (Date)</b>	<b>Title</b>	<b># Studies or Reviews (Year Range)</b>	<b>Main Conclusions</b>
LaForme Fiss & Effgen (2006)	Outcomes for young children with disabilities associated with the use of partial body weight supported treadmill training: an evidence based review	15 studies (1997-2005)	There is no definitive proof that PBWSTT alone increased the ambulation abilities of the children in these studies. This review is unable to provide evidence based practice guidelines; equally it does not suggest that the intervention is not effective.

PBWSTT requires the direct intervention of a therapist, relatively major equipment, and appropriate space for the equipment and intervention. These requirements make it more difficult to use this intervention in the natural environments of a school setting; however, most high school athletic programs have treadmills and there are now portable, low-cost treadmills for younger children so it is not unrealistic to consider using this intervention in a school setting.

In summary, there appears to be a trend in the successful use of PBWSTT; however, stronger research needs to be completed to confirm the findings of the limited evidence currently available. As more evidence on outcomes and the specifics of required protocols become available, school therapists should carefully consider the appropriateness of this intervention in a school setting.

### **Passive Stretching to Improve Range of Motion (PROM)**

Although improving ROM is not a functional goal of intervention, we often have observed passive stretching for students with disabilities, particularly with severe CP.

**Table 11. Passive Stretching to Improve Range of Motion**

<b>Authors (Date)</b>	<b>Title</b>	<b># Studies or Reviews (Year Range)</b>	<b>Main Conclusions</b>
Leong (2002)	Critical review of passive muscle stretch: Implications for the treatment of children in vegetative and minimally conscious states	17 studies (1960-2000)	Research on passive muscle stretch to improve PROM and is inconclusive.
Pin, Dyke, & Chan (2006)	The effectiveness of passive stretching in children with CP	4 studies (earliest date of database to April, 2006)	No conclusive evidence supports the effectiveness of PROM exercises. The clinical significance of any reported increases is unknown.

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Leong (2002) published a critical review of research on the effects of passive muscle stretch as an intervention, as shown in **Table 11**. The author wanted to determine implications of passive stretch for children in “vegetative and minimally conscious states” (p. 169); but identified no research that specifically addressed children in these states. Leong expanded the review to include studies (no case reports) in which participants were children or adults with acquired brain injury, CP, or stroke, and the intervention was PROM, prolonged muscle stretch, or serial casting.

The 17 studies meeting Leong’s (2002) inclusion criteria had several combinations of independent and dependent variables: (a) effects of repeated PROM on spasticity (1 study); (b) effects of one session of PROM on spasticity (3 studies); (c) effects of prolonged muscle stretch on PROM and spasticity (3 studies); and (d) effects of serial casting on PROM and spasticity (10 studies). In 8 of the 17 studies, the participants were children and ROM was a dependent variable. The intervention in 3 studies was passive muscle stretch (Lespargot, Renaudin, Khouri, & Robert, 1994; McPherson, Arends, Michaels, & Trettin, 1984; Miedaner & Renander, 1987). Serial casting was the intervention in the other 5 studies (Corry et al., 1998; Flett et al., 1999; Hill, 1994; Tardieu, Tardieu, Colbeau-Justin, & Lespargot, 1982; Watt et al., 1986).

The author evaluated the quality of each individual article as Levels I–V according to the criteria of Guyatt, Sackett, & Cook (1993) and then graded the strength of the evidence for each intervention according to the CEBM’s (2001) Grades A through D. Grade A recommendations, the strongest recommendations, were supported by consistent Level I studies, Grade B recommendations were supported by consistent Level II or III studies or extrapolations from Level I studies, and Grade C recommendations were supported by Level IV studies or extrapolations from Level II or III studies. Grade D recommendations were supported by Level IV studies or any study that was inconsistent or inconclusive. Extrapolations meant the clinical situation had potentially important differences from the study situation. No Grade A recommendations resulted from the review. The study by Miedaner and Renander (1987) supported a Grade B recommendation for manual passive stretch held 20-30 seconds for 5 repetitions twice a week found to be as effective as the same intervention provided 5 times/week. A Grade C recommendation for PROM held for 60 seconds for 5 repetitions 3 times/week for reduction of knee flexion contractures came from the study by McPherson et al. (1984). The study by Lespargot et al. (1994) provided a Grade C recommendation for stretching of adductor muscles 5-7 hours/day to prevent adductor contractures.

Four of the 5 studies found that serial casting increased ROM, at least relatively soon after removal of the case. The exception was the study by Watt et al. (1986), which found no increase. The overall results led to a Grade B recommendation.

Based on the reviewed studies, Leong (2002) concluded that “the support for passive range of motion and prolonged muscle stretch in improving range of motion...is inconclusive” (p. 181). Most recommendations were supported by only one study; and no Level I studies were found. Other problems were lack of carryover or only short-term measurement of effects. With the exception of the Miedaner and Renander study (1987), only one lower extremity joint was studied, although children with neuromuscular conditions often have limitations at more than one joint. The findings of Leong’s review (2002) were consistent with the findings of a more recent review by Pin, Dyke, and Chan (2006), which evaluated research on effects of passive stretching

in children with CP. The inclusion criteria for studies in their review were: (a) participants were under age 18 years and had CP; (b) the independent variable was passive stretching and effects were measured; (c) any level of evidence except expert opinion; and (d) studies were reported in peer-reviewed journals. They excluded studies that compared passive stretching with medications, surgery, or serial casting. These authors scored the quality of each study using the PEDro scale (CEBP, 1999) and graded the levels of evidence for the effectiveness of the intervention using the AACPDM criteria (2004).

We found 4 studies that measured the effect of PROM exercises on ROM measurements. Three studies were also included in the Leong (2002) review (Lespargot et al., 1994; McPherson et al., 1984; Miedaner & Renander, 1987) and 1 study was published subsequently (Fragala, Goodgold, & Dumas, 2003). A Level II study by Fragala et al. included 7 children. In 2 of the 7 children, hip and knee ROM decreased when once or twice weekly passive stretching was discontinued during a 5-week school vacation, but ROM did not decrease during a 2-week school vacation. The researchers did not control for positioning programs at home and/or school.

In summary, Pin et al. (2006) agreed with Leong’s (2002) conclusion that no conclusive evidence supports the effectiveness of PROM exercises. The clinical significance of any reported increases in ROM also is unknown; and no research has investigated relations between passive stretching and individualized education program [IEP] goals or other functional skills. Another problem is that none of the studies compared a prolonged stretch with PROM exercises, although a prolonged stretch may be more effective (Tardieu, Lespargot, Tabary, & Bret, 1988).

## Strengthening for Children with Cerebral Palsy

Strengthening weak muscles to improve performance and function is a deeply rooted procedural intervention used by physical therapists. The widespread use of muscular strengthening programs is supported by the number of books and entire journals devoted to the topic. Strengthening programs are commonly used to strengthen individual muscles and groups of muscles to improve function in children having a variety of disabilities. Evidence supporting specific strengthening programs for children is quite variable depending on the specific diagnosis. See **Table 12**.

**Table 12. Strengthening**

Authors (Date)	Title	# Studies or Reviews (Year Range)	Main Conclusions
Darrah, Fan, Chen, Nunweiler, & Watkins (1997)	Review of the effects of progressive resisted muscle strengthening in children with CP: a clinical consensus exercise	7 studies	The group concluded that progressive resisted exercise of isolated muscle groups increased muscle performance in clients with CP, but the relationship between strength training and functional abilities remains unclear.
Dodd, Taylor, & Damiano (2002)	A systematic review of the effectiveness of strength-training programs for people with CP	11 studies (1966-2000)	“The trials suggest that training can increase strength and may improve motor activity in people with CP without adverse effects.”

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Muscle strengthening programs have not been universally accepted for children with disabilities involving upper motor neurons or degenerative disease. Only in the past decade through the research of Damiano and colleagues (e.g., Damiano & Abel, 1998) have improvements in functional outcomes for children with CP been documented after muscle strengthening programs. Previously, children with CP were not considered to have weak muscles and activities to strengthen muscles were thought to increase spasticity.

In 1997 Darrah and colleagues completed a systematic review of 7 articles on the effects of progressive resisted muscle strengthening as an intervention for children with CP. Using levels of evidence from Sackett, they found 1 study classified as Level I evidence and the remaining 6 studies as Level V evidence. There was improvement in performance of individual muscles or groups of muscles after the resisted exercise program in all of the studies. In the 3 studies that evaluated muscle spasticity there were no deleterious effects.

Dodd, Taylor, and Damiano (2002) completed a systematic review of 11 studies examining strength training in children with CP published between 1966 and 2000. Articles were included with a PEDro score over 3. The highest score achieved was 6 out of 10 with a median score of 4. Only 1 randomized trial was included in the review (McCubbin & Shasby, 1985). Eight of the articles reported improvements in strength. In the studies reporting positive strength-training effects, there was heterogeneity of effect size ranging from 1.16 to 5.27. No negative results were reported, including no change or reduction in spasticity after the strengthening program (MacPhail & Kramer, 1995; Tweedy, 1997). Two studies reported improvements in activity. Damiano and Abel (1998) found significant increases in walking, running, and jumping as measured by the Gross Motor Function Measure. MacPhail and Kramer (1995) found improvements in standing. Darrah, Wessel, Nearingburg, and O'Connor (1999) reported improvements in self-perception. Six of the strengthening programs reviewed were provided individually to the children, 4 did not indicate how the program was administered, and 1 program (Darrah et al., 1999) was a group program. Dodd, Taylor, and Damiano (2002) concluded that the evidence supports strength training for increasing strength in children with CP without increasing spasticity or muscle tightness. However, these authors stated more rigorous studies examining strengthening as an intervention need to be completed.

The APTA Section on Pediatrics appointed a Task Force to develop practice recommendations for clinical management of children with CP. Based on national input and systematic study, their comprehensive report, *Spastic Diplegia: Achieving Functional Mobility Outcomes* (O'Neil et al., 2006) noted that for children aged 6-21 years, strengthening during play and/or direct resistive exercises should be considered. The report suggests using theraband, cuff weights, free weights, weight machines, and other exercise equipment. They conclude, based on the Dodd et al. (2002) review and the work of Damiano and colleagues (Damiano, Kelly, & Vaughn, 1995; Damiano & Abel, 1998) that to demonstrate an increase in strength, the program should be 2-3 times/week for 10 weeks at 65% of maximum isometric strength or 3-10 repetitions maximum. At least 10 weeks of strength training is recommended for increasing or maintaining strength.

In summary, continued research is required to identify the most effective and efficient strengthening protocol to use, specifically how to improve functional tasks for children with all disabilities. None of the reported research was performed in school settings; however,

strengthening programs are part of many school physical education and school athletic programs, so it is likely that this intervention can be relatively easily accomplished in most school settings.

## Weight Bearing Interventions for Children with Cerebral Palsy

Physical therapists often provide weight bearing interventions for children with CP in an attempt to increase or maintain ROM, reduce spasticity, or improve bone growth and bone mineral density (Stuberg, 1992). Pin (2007) published a systematic review of studies examining the effects of upper and lower static weight bearing in children with CP. The review included English language research studies of children with CP under age 18. The author used the PEDro scale to evaluate the quality of the studies and the AACPDm evidence table to grade the levels of evidence of each study. Ten studies meeting the inclusion criteria were included in the review as shown in **Table 13**.

**Table 13. Weight Bearing Interventions for Children with Cerebral Palsy**

Authors (Date)	Title	# Studies or Reviews (Year Range)	Main Conclusions
Pin (2007)	Effectiveness of static weight bearing exercises in children with CP	10 studies (earliest date in database to October, 2006)	Research on effects of upper extremity weight bearing on hand function is inconclusive and clinical significance of studies with positive results is unclear. Standing to provide a prolonged muscle stretch reduces spasticity temporarily, but relevance is questionable. Static standing in a standing frame increases bone mineral density, but association with incidence of fractures needs to be studied.

Three studies examined upper extremity weight bearing. All were Level IV single-subject designs that assessed change in muscle tone by measuring contact area of the hand. None of these authors, however, explained the relationship between contact area and muscle tone. Two of these studies found increased hand contact area after weight bearing, but the effect was not sustained following hand activities. Four studies examined the effect of weight bearing on hand function, such as prehension, reaching, and grasping. Two Level I studies and 1 Level IV study found improved hand function following upper extremity weight bearing activities or negative outcomes after discontinuing weight bearing. One Level IV study showed no difference in hand function following weight bearing. Pin (2007) concluded that the evidence supporting a positive effect of weight bearing on hand function is inconclusive because of conflicting results and low levels of evidence or methodologic quality of the studies that showed some benefit. The clinical significance of the findings also is unclear.

One Level I study compared children's Jebsen-Taylor Hand Function Test scores when they were supported in sitting and when weight bearing on a prone stander. Simulated feeding scores were faster in standing and picking up small object scores were faster while sitting; however, the effect sizes were small, and the functional relevance is unknown.

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Two Level I studies measured the effect of standing to provide a prolonged muscle stretch on lower extremity spasticity in children with CP. Both studies showed a temporary reduction in spasticity, but the effect sizes were fairly small, and the clinical importance is questionable (Pin, 2007).

Three studies examined the effect of lower extremity weight bearing on bone mineral density. Two of the 3 studies provided Level 1 evidence that weight bearing using a stander (Caulton et al., 2004) and weight bearing activities (Chad, Bailey, McKay, Zello, & Snyder, 1999) increase bone mineral density (BMD) in the lumbar spine or femur of children with CP. Caulton et al. increased the time children stood in a standing frame by 50% for 9 months, and Chad et al. engaged the children in 8 months of weight bearing physical activities, which were not well defined. A case series (Gudjonsdottir & Mercer, 2002) had similar findings. The children reported in the case series stood in either a dynamic stander (a motor provided reciprocal loading and unloading of the lower extremities) or a static stander for 30 minutes/day for 5 days/week for 8 weeks. The 2 children who used a dynamic stander and 1 of the 2 children who used a static stander had increased BMD in the lumbar spine and proximal femur.

In summary, Pin (2007) concluded that static weight bearing “in a standing frame is a simple but effective way to increase BMD in children with cerebral palsy” (p. 71). The association between increased BMD and incidence of fractures, however, still needs to be studied. The effect of lower extremity weight bearing on function also needs to be examined. The evidence on the effect of weight bearing on hand function is inconclusive, and the clinical significance of any positive findings is unclear.

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## DISCUSSION

This project started by searching for research on over 20 interventions that physical therapists commonly have used for children with disabilities. Our results yielded 13 systematic reviews on 9 interventions, with no meta-analyses. The newest interventions—CIT and treadmill training—were first studied in adults and then in children. Research on these interventions has now moved from funded projects with adults to funded projects with children. These two areas have the strongest and most recent research support, although specific protocols to achieve specific outcomes require further investigation. Traditional common interventions for children with disabilities, such as NDT and PROM, have enough research for systematic reviews but little evidence to support their effectiveness. Given the paucity of support, these interventions should be used only after careful consideration of the situation of a particular child and the therapist's past clinical experience with these interventions based on measurable, successful outcomes. As with any intervention, progress and outcomes must be systematically measured to ensure that the intervention is effective for an individual child—and is changed if it is not.

Research supports positive effects of seating adaptations on the function of children with disabilities, but the types of adaptations and the outcome measures were not consistent across studies. Two of the most common adaptations, which probably are important for children who lack good postural control, were stabilization of the pelvis and orientation in space of 0-15 degrees, with a seat sloped forward 0-15 degrees. More research is needed, not only to further examine effects of various seating adaptations on function, but also to determine effects of positioning in other devices, such as standing and sidelying, on education-related activities of children with disabilities.

CE is an intervention method that parents often request and is a frequent area of dispute in school settings (Feinberg, Beyer, & Moses, 2002). Systematic reviews indicated that CE is as effective as traditional physical therapy when intensity of intervention is controlled. The lack of significant benefits of CE over traditional physical therapy coupled with the findings of Stiller et al. (2003), which suggest that intensive therapy is more effective for children with CP than CE or special education services, raises concerns about this intervention. The intensive and integrative nature of CE, combining education and therapy into meaningful, functional activities, however, could serve as a best-practices model for therapeutic interventions.

Research on the effects of passive stretching on ROM is inconclusive, with some studies finding no effect and other studies finding some effect for some children. The functional relevance of any reported increases was not reported. Most studies had small sample sizes, and extraneous variables were not well controlled, which also makes drawing conclusions difficult. Based on available research, PROM exercises may maintain or increase ROM in some children, but the functional relevance should be questioned. Joint ROM is one of the easiest evaluation measures to take and physical therapists who decide to use PROM exercises as an intervention to achieve a child's goals must systematically and regularly take, record, and compare measurements across time to determine if the exercises are effective. Taking measurements following periods without exercises to see if range decreases could be particularly informative. Although research has not yet compared PROM exercises with the prolonged stretch provided by standing in a stander, research does support an effect of a prolonged stretch, and teams should consider the potential

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benefits of standing on ROM. Research does support a positive effect of weight bearing, including standing in a stander, on bone density.

Muscle strengthening, a well-accepted intervention used by physical therapists, now has a body of research to support muscle strengthening programs for children with CP. The most effective intervention protocol to achieve specific outcomes, however, is not yet clearly defined. Given the interest in this line of research, more specific answers should be available in the near future. Research on the effectiveness of muscle strengthening programs for children with other disabilities, however, is surprisingly lacking. Some literature suggests that strength-training programs can increase muscular strength in children aged 13-18 years with Down syndrome (Weber & French, 1988) and children with myelomeningocele (O'Connell & Barnhart, 1995). Resistance exercise using isokinetic equipment with children ages 6-14 years with juvenile rheumatoid arthritis has led to improvements in strength, endurance, functional status, disability, and performance in timed tasks (Fisher, Venkatraman, & O'Neil, 2001). Children with juvenile rheumatoid arthritis have also shown improved aerobic performance after moderately vigorous aerobic activity for at least 30 minutes twice a week for 6 weeks (Klepper, 2003).

Research supports positive effects of lower extremity casting on dorsiflexion ROM of children with CP, but the long-term effects and influence on ambulation are unknown and are questionable. Orthoses that limit plantar flexion, for example, may improve heel strike during ambulation, but make movement on the floor or rising from the floor to a standing position difficult. Effects of different orthoses on various activities of individual children need to be measured and monitored.

Few of the systematic reviews included studies that addressed the issue of the specific protocol to achieve specific outcomes. Nor do they address the most efficient frequency, intensity, and duration of physical therapy intervention or practice of a desired motor skill. This is a critical topic requiring significant investigation. Physical therapy intervention is costly and takes time away for other learning opportunities for the child. Knowing how to provide sufficient but not excessive intervention to achieve the desired outcomes is the aim. While receiving a great deal of verbal discussion, this topic has rarely been studied, and no systematic reviews were identified. A British study by Bower, McLellan, Arney, and Campbell (1996) found that 2 weeks of intensive intervention (1 hour/day, 5 days/week) for children with CP had a positive effect on their GMFM scores. Bower, Michell, Burnett, Campbell, and McLellan's later study (2001) with a similar intensity and frequency of intervention but 6 months duration found little difference in the GMFM scores; and therapists and parents reported feeling tired and stressed. Trahan and Malouin (2002) found improved performance on the GMFM after a period of intensive, 45 minutes, 4 times/week for 4 weeks, in children with severe CP, as did Tsorlakis, Evaggelinou, Grouiosm, and Tsorbatzoudis (2004), over 16 weeks, 4 times/week. These few studies begin to suggest that 6 months of intensive intervention is not more effective than less frequent, intensive intervention, but that perhaps 2-4 weeks of intensive intervention might be appropriate for children with CP to achieve specific gross motor skills.

The only U.S. study (Schreiber, 2004), a Level V case report, found that physical therapy intervention, 1 hour, 4 times/week for 4 weeks, was a good intensity, frequency, and duration. Schreider (2004) noted that his subject started the intense intervention when she was at a critical period for motor skill acquisition. He suggests that the intervention success was probably tied to

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the intensive intervention occurring during a critical/sensitive period of skill development. Bower et al. (1996) also noted that intensive “bursts” of intervention may be most appropriate to help a child change from “could do” a motor skill to “does do” a motor skill, as opposed to moving from “can’t do” to “does do.”

These few studies along with the data supporting high-intensity intervention and practice for successful CIT and treadmill training might suggest that high intensity is a key element of effective intervention. Further investigation, especially studies of children in schools in the U.S. is needed to assist in determining the most appropriate frequency, intensity, and duration of intervention and whether increasing intensity during critical periods of skill acquisition facilitates the rate of motor skill development.

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## SUMMARY

IDEA 2004 requires special education and related services to be “based on peer-reviewed research to the extent practicable” (§300.320(a)(4)). In physical therapy, the body of peer-reviewed research to provide guidance for decisions about services for children with disabilities is somewhat limited. Research carried out with children receiving physical therapy services in schools is particularly limited. The paucity of research does not mean, however, that therapists working in schools should wait for research to be conducted or to use only those practices for which research is available. The best research evidence may be a single-subject design study on a particular intervention, which, depending on the therapist’s clinical expertise and the student’s unique values and circumstances, may appear to be a good option for intervention.

Regardless of whether the intervention has a strong base of evidence or sufficient research support, therapists must measure and report students’ progress during intervention and outcomes following intervention. David (1996) provided a good example of monitoring progress toward goals that teams identify as requiring physical therapy intervention. She noted that if monitoring indicates a child is not making the anticipated progress, then a change in the intervention, intensity, or other factor is indicated. Achievement or non-achievement of IEP goals also must be measured and documented. Another method of measuring outcomes is to compare baseline and outcome data using tools that assess meaningful, functional skills that are included on the IEP. Two tools appropriate for elementary school children are the School Function Assessment [SFA] (Coster, Deeney, Haltiwanger, & Haley, 1998) and the Pediatric Evaluation of Disability Inventory [PEDI] (Haley, Coster, Ludlow, Haltiwanger, & Andrellas, 1992). The PEDI also can be used to measure outcomes of older students whose functional skills are developed to a level lower than those of a typical 7-year-old child.

Additional research clearly is needed to identify physical therapy interventions that are effective or most effective for helping children with disabilities achieve their IEP goals and have access to and participate in their educational programs. However, a major problem has been lack of funding necessary to study physical therapy interventions that have promise for improving outcomes for children with disabilities. We urge agencies responsible for the health and education of students with disabilities to increase the availability of funding for research that will answer important questions about effective school-based physical therapy services. Based on our review of current research evidence and knowledge of common and emerging practices, we recommend that future research focus on the following areas:

- Interventions shown to be effective in laboratory or other controlled environments must be studied with students with disabilities in school and other educational environments in which school-based physical therapists work with students with disabilities.
- Interventions that apply motor-learning principles have promise, but research on the effects of motor-learning interventions on acquisition of meaningful motor skills in children with disabilities in schools is lacking. Research is especially needed to study aspects of motor-learning intervention, such as intensity, schedule, and type of practice and feedback.

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- Research is needed to identify and develop measures and methods that can predict relevant outcomes of students with disabilities.
  - Research is needed to determine the most effective and efficient duration, frequency, and intensity of both physical therapy intervention and practice of motor skills.

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