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Rehabilitative Therapies in Cerebral Palsy: The Good, the Not As Good, and the Possible

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Abstract

In the past decade, growing recognition of the importance of motor activity for the development and maintenance of central nervous system pathways and for recovery of function post injury has provided new avenues for rehabilitation. Physical therapy is likely to have a prominent role in stimulating neuroplastic changes in damaged developing nervous systems that may finally alter the natural history of these disorders, which has not yet been possible. In this article, we discuss the scientific evidence for various physical therapy treatment options for children with cerebral palsy. Newer, more intense, and task-related exercise programs show the strongest level of evidence. Traditional approaches and newer "packaged" approaches have failed to provide evidence of superiority. Their continued prevalence among clinicians is puzzling and disconcerting, as evidence supporting other approaches continues to accumulate.

Keywords

physical therapy; outcomes; motor activity; plasticity; exercise

Cerebral palsy encompasses a "group of disorders of movement and posture causing activity limitation attributed to a static disturbance in the developing brain, often accompanied by associated impairments and secondary health conditions."[1] Nearly all individuals with cerebral palsy receive physical therapy services in childhood, often regularly for many years. The main question is whether the scientific evidence for the efficacy or effectiveness of physical therapy justifies its frequent use in this population. We will also discuss the recently emerging therapy approaches with significant potential for altering the current neurological prognosis for those with this disorder.

The amount of evidence supporting or failing to support the effectiveness of physical therapy for children with cerebral palsy has increased exponentially in each of the past 2 decades. Reasons for this include (1) academic progress within the physical therapy profession, including a greater number of PhD-trained therapists and elevation of the basic education level for therapists from a bachelor's to a doctoral degree and (2) factors outside of the profession, such as a greater focus on evidence-based practice in all medical and allied health fields and increased pressure from third-party payers to demonstrate efficacy of therapies.

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The definition of an intervention's "success" has also changed and has been spearheaded by efforts such as the International Classification of Functioning, Disability and Health by the World Health Organization.[2] It is no longer sufficient for a medication, procedure, or exercise regimen to reduce impairments at the level of body structures and functions. Treatments cannot be justified unless they produce a change in activity, participation, or, more elusively, health-related quality of life for the person receiving the intervention. This is clearly a higher but critically important standard and one that meshes well with the stated mission of physical therapy, which is to promote functioning and ease disability.[3] Some of the success of physical therapy in the areas of activity and participation may be attributable to patient education efforts that have not been well-studied or validated. For children with cerebral palsy, this could involve teaching parents how to best handle their infant to promote motor development and advice on or provision of assistive devices to promote mobility. However, the goal of this article is to review the evidence supporting the *direct* treatments physical therapists may provide. Physical therapy is a discipline and does not indicate what types of exercises are being performed. As a result, it is important to point out that studies evaluating the effects of "therapy" in general or effects of another treatment combined with "therapy" without providing details of what was done in those sessions have no practical or scientific use. Not only the type of exercise but also its "dose"—or frequency, intensity, and duration—and the intended goal of the intervention must be specified to evaluate its success.

Treatment Effectiveness or Efficacy in Cerebral Palsy

The "Good"

Dramatic positive changes in motor function from any intervention are rare in this diverse, complex chronic disorder, even from very invasive surgical approaches. Given these tempered expectations, which physical therapy treatments have emerged through scientific study as most likely to produce significant motor benefits?

A recent review of review articles summarized the evidence for different treatment categories that have been evaluated scientifically.[4] Four approaches emerged as demonstrating positive effects on impairments at the level of body structures to activity: (1) intensive upper-extremity training on bimanual performance, (2) strength training on muscle strength, (3) hippotherapy on muscle symmetry and activities, and (4) balance training on reactive balance.

Intense upper limb training paradigms such as constraint-induced movement therapy and bimanual training have the strongest evidence for improving upper limb functioning primarily in children with hemiplegia, similar to results in the stroke population.[5,6] Optimal dosing strategies, whether to provide unilateral or bimanual practice, optimal age to begin therapy, possible adverse effects on the development of the less-affected extremity and associated cortical pathways, and other research questions remain to be answered. Although this intervention has only been described for 1 subtype of children with cerebral palsy, the effectiveness of deliberately training an underused limb through repetitive practice is now an established and pervasive rehabilitation principle. Basically, people with a motor disability have difficulty moving an extremity and develop learned nonuse because neural changes occur in response to low amounts of activity. The goal of therapy is to reverse this by "forcing" them to practice using that limb. Ideally, intervention should be more proactive and not allow the nonuse pattern to be set in motion, because it is easier to learn a behavior without first having to unlearn another one.[7]

Strength training is now one of the most well-studied therapy approaches in cerebral palsy. The use of this intervention flourished once it was safely shown that the effort associated with resistance training did not appear to exacerbate spasticity, which was a long-held clinical dogma.[8,9] Strength or resistance training has been the subject of several systematic reviews

and has been included in reviews of different therapy approaches to improve gait or other aspects of motor function.[10–13] The general consensus across studies is that strength can be predictably increased through a properly designed short-term program.[10] Measurable functional benefits have been demonstrated in some, but not all, studies.[11] Training for only a few weeks may not be sufficient to produce a significant change in activity and a longer training period may be required.[13] Strength training very likely needs to be continued regularly to retain benefits. Strengthening in functional positions may transfer more readily to improvement in motor tasks; however, it is uncertain whether it is the loading or the functional practice that makes the difference. A recent evidence-based report on aerobic training in this population found similar results to those from strengthening programs in that endurance training typically resulted in direct physiological benefits, but the effect of endurance training on activity and participation had not yet been adequately evaluated.[14]

Arguably one of the most prevalent and successful examples of task-related training in the lower extremities is body-weight-supported treadmill training. The first published study on the use of this intervention in cerebral palsy was in 2000 and demonstrated marked improvement in the gross motor function measure standing dimension and walking, running, and jumping dimension in 10 children with cerebral palsy.[15] Gait speed and the gross motor function measure are the most commonly reported outcomes in treadmill training studies, and results across studies are generally positive, with moderate to large effect sizes.[16] Weight support may or may not be a component of these programs and optimal progression strategies as well as indicators for when to discontinue the training are not yet established. The major rehabilitation principle underlying the success of these programs is repetitive task practice, and studies in stroke and spinal cord injury suggest that overground gait training of the same intensity may produce equivalent results.[17,18] Devices that support and assist leg movement during stepping, such as the Lokomat, have also been used in cerebral palsy[19] as well as in spinal cord injury and stroke with positive results, although their superiority over therapist-assisted training has not been established. These devices can provide either support, similar to harness systems, or resistance to movement to make training more challenging for those who are developing greater force in or use of their legs. It has recently been shown that if the rhythm imposed by an external device such as this is too regular, the spinal cord pathways will habituate to it, which would lessen its effect.[20] Modifications to the controller and incorporating voluntary movement with the passive motion can overcome this limitation.

In summary, in the past decade increased intensity in the amount of practice or the physiological demands of the exercise and increased task or functionally based training constitute major trends in physical therapy treatment of cerebral palsy and are associated with the highest level of evidence.

The “Not as Good”

The first randomized clinical trial evaluating physical therapy in cerebral palsy was published more than 20 years ago. It compared neurodevelopmental therapy,[21] which was the predominant therapy approach for decades, to an infant stimulation program. The results were disconcerting to many therapists because not only was the physical therapy intervention not found to be superior, but at the 6-month point the mean motor quotient was lower in the neurodevelopmental therapy group, as was the mean mental score, and those in that group were less likely to walk. At 12 months, no group differences in the incidence of contractures or need for bracing or orthopedic surgery were found. Subsequent studies have failed to “overturn” these conclusions. A systematic review[22] of neurodevelopmental therapy in 2001 stated that while it could not be concluded that this approach was effective or ineffective, “the preponderance of results … did not confer any advantage to neurodevelopmental therapy over the alternatives to which it was compared.” Similarly, a systematic review of therapy for high-

risk infants[23] basically concurred with the study decades before that intervention in accordance with the principles of neurodevelopmental therapy does not have a beneficial effect on motor development, whereas specific or general developmental programs can have a positive effect.

Therapies that involve multiple types of exercises, such as neurodevelopmental therapy and, more recently, Adeli Suit programs and Conductive Education, are an issue from a scientific standpoint because they each have multiple components that are likely to have varying degrees of evidence. These programs should be dissected so that the active ingredients can be identified and retained if superior to other alternatives and ineffective ones discarded. The fact that none of these have failed to demonstrate superiority over any alternative treatments to which they have been compared is also a concern.[24] The same review of review articles that supported the efficacy of upper limb training failed to support the effectiveness of conductive education, an approach that has achieved widespread international interest in recent years.[3] Some packaged programs have achieved a grassroots popularity, regardless of weak scientific support and some contain unusual equipments, such as a suit adapted from one designed for Russian cosmonauts or special plinths and ladders, which are of uncertain benefit. Some may even cause harm if not implemented according to basic known principles (eg, bungee-type cords used in the adapted suit to reduce hip internal rotation in stance, much like previous twister cables orthoses, may provide resistance to and therefore reinforce the strength of the overactive muscles). This would in effect promote unwanted motor patterns, while the intention was supposedly to control them. Their cost and time-efficiency should also be considered as well as the fact that the choice by families to use these alternative approaches may limit their use of more effective therapies.

Passive stretching is an example of a very common longstanding component of physical therapy programs in cerebral palsy. A review of the evidence, however, has failed to demonstrate any lasting benefit.[25] This seems surprising because stretching is an important component of maintaining muscle flexibility.[26] What may occur in cerebral palsy is that this is either underdosed or ineffective because of competing influences such as immobility or unwanted muscle activation as a result of spasticity or dystonia. More intensive stretching programs or the use of orthoses or casts may enhance effectiveness of passive stretching; however, increased active amount and range of movement and dynamic stretching may ultimately prove even more effective. More research is clearly needed to address the use of exercises or devices to maintain or progressively increase muscle length in cerebral palsy. Therapy alone may not sufficiently maintain muscle length in this population, which has a high risk of developing contractures. More invasive procedures such a botulinum toxin injections or selective dorsal rhizotomy procedures may prove far more effective and cost- and/or time-efficient for accomplishing this treatment goal.

The Possible

It appears we are just at the cusp of envisioning what may be possible in the not too distant future with respect to stimulating neural recovery in cerebral palsy. The previous therapy paradigm was to encourage maximal motor performance given the fixed constraints of the primary neurological injury. In the 1990s, the importance of minimizing secondary consequences of the activity limitation imposed by the brain injury, especially from a proactive (preventive) rather than a reactive standpoint, came to the fore-front. The increased use of strength training in cerebral palsy is one outcome of this new emphasis.

The primary injury is no longer thought to be immutable and some neural and behavioral recovery is now considered possible in cerebral palsy. Cortical reorganization in response to training paradigms has now been shown to be possible in those with brain injuries, with these changes coincident with functional gains. Recent advances in neuroscience have highlighted the importance of motor activity for the establishment and reinforcement of neural pathways,

[27] with the converse occurring when activity is reduced.[28] In this decade, much research has been published that highlights the neural effects of different types of motor training or exercise. For example, it has been shown motor skill training increases corticospinal excitability, whereas strength training does not.[29] Important differences have also been found in "forced" versus voluntary exercise with the amount of work being equal.[30] Activity may be even more critical for those with motor disabilities and has implications for all aspects of their development.[31] Clearly, far more work needs to be and is being done to determine the specific effects of different exercise types and doses and how these can be combined with pharmaceutical or other (eg, stem cell–based) approaches to optimize recovery or restoration of function.

The remarkable plasticity of the neuromuscular system is a double-edged sword in cerebral palsy. Muscles and neural pathways are constantly changing in response to motor activity, with the potential for both positive and negative changes, which are far greater at a younger age. [32] This provokes a sense of urgency to not only determine the optimal strategies to promote adaptive changes but also to ensure that we are not allowing maladaptive changes to occur through lack of adequate intervention or delaying intervention. As pathways are "pruned" throughout the course of early development, the potential for a more complete recovery may diminish, so timing is likely to be a critical factor.

We now know that specific types of training or maternal and/or cultural handling practices can alter the rate of motor development. For example, the results from a randomized controlled trial of in-home treadmill training for infants with Down syndrome demonstrated accelerated walking acquisition by 4 months compared with controls. [33] Similarly, the new recommendation to place babies in supine rather than prone for sleeping is delaying motor development in infants due to less practice in trunk and proximal joint extension.[34] Far earlier identification of children at high risk for developing cerebral palsy is now possible through the use of tests such as the Test of Infant Motor Performance[35] or the evaluation of General Movements, [36] so intervention can be initiated earlier. What is not yet known is which types of movements or motor tasks should be encouraged and when, and whether external devices are needed to encourage or augment these. In children with cerebral palsy, the hallmark of which is a deficit in motor control, the challenge is not merely to accelerate motor task acquisition but to enrich the repertoire and coordination of the movements involved in that task. As a note of caution, overstimulation of infant behaviors may be counterproductive or even harmful, so any novel approach must be rigorously evaluated before clinical implementation.

Translating Evidence into Clinical Practice

Change in physical therapy appears to be slower than in many medical fields, perhaps because the sense of urgency and the consequences of doing a certain exercise or not doing it are not as great as if one were administering or failing to administer a life-preserving medication or performing an invasive procedure. Major ethical issues with respect to prematurity have arisen as medical care has advanced, but ethical dilemmas in pediatric rehabilitation management are rarely discussed yet are nevertheless imperative to consider. For example, it is unethical for therapists not to base practice on the best medical evidence.[37] The tremendous variability in physical therapy practice across therapists, settings, and geographical regions indicates there is either a lack of evidence in the field or a failure to incorporate evidence. The balance is clearly shifting in recent years from the former to the latter, and our profession must now address how best to translate evidence into practice in a timely manner. Models of therapy delivery or exercise promotion are also evolving and we need to determine the role of direct therapies versus integrating exercise strategies and activity promotion within the context of everyday life.

Conclusion

Pediatric physical therapists, in conjunction with the medical team, have a fundamental role in identifying infants at risk for motor delays, educating families about their child's disability, and recommending assistive devices to promote mobility or function. Scientific scrutiny of direct therapy interventions has revealed a limited hierarchy of treatments that are beginning to demonstrate greater effectiveness than previous options, although the potential for altering motor prognosis in cerebral palsy remains limited. Newer approaches that involve more intense and complex training strategies are beginning to exploit the inherent potential for adaptive neural plasticity and recovery, the limits of which are not yet known but offer great promise for the future.

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