The Use of Resistance Training as an Intervention for the Treatment of Gait Dysfunction in Children with Spastic Cerebral Palsy

D Lehman, A Garban, L Scott, C Tant, D White

Citation

D Lehman, A Garban, L Scott, C Tant, D White. *The Use of Resistance Training as an Intervention for the Treatment of Gait Dysfunction in Children with Spastic Cerebral Palsy*. The Internet Journal of Pediatrics and Neonatology. 2007 Volume 9 Number 1.

Abstract

The purpose of our literature review was to analyze the strength of research evidence using the Sackett Classification Method, in an effort to identify science related to resistance training and improvement of gait dysfunction in children with spastic cerebral palsy (CP). A literature search of EBSCO host was conducted and articles were chosen from peer-reviewed journals, written in the English language, dating from 1991-2006. Nineteen articles were critically reviewed. The articles addressed resistance training interventions, gait assessments, intra-limb coordination, muscle evaluation, physical therapists' perceptions, and physical therapy interventions. None of the articles reviewed suggested a negative effect from resistance training intervention in the treatment of cerebral palsy, and the evidence justifies the use of strength training for the improvement of gait in this population.

INTRODUCTION

Two children out of every one-thousand live births in the United States are diagnosed with cerebral palsy (CP), making this the most common cause of physical disability in children. CP is a non-progressive disorder that is acquired prenatally, perinatally, or postnatally resulting in motor, cognitive, sensory, endocrine, or urogenital impairments. The exact cause of CP is unknown; however, prenatal asphyxia and infection are factors that may be involved [1]. There are many types of CP, with spastic CP being the most prevalent, characterized by abnormal patterns of posture and movement with increased tonicity throughout the limbs.

With increased limb tonicity, functional tasks such as activities of daily living, transferring, bed mobility, and ambulation are difficult. As a result, individuals with spastic CP and their families depend on rehabilitation teams to address their functional limitations, and to provide assistance when working toward their optimal level of function. Physical therapy intervention specifically focuses on improving the child's functional independence, most typically as it relates to ambulation. Walking abilities may be altered secondary to deficits in balance, endurance, range of motion, coordination, and/or strength [1]. Current literature indicates that lower extremity (LE) weakness is a primary impairment associated with gait deviations in children with spastic CP [2,3,4].

During this literature search, the authors of this paper discovered a distinct controversy regarding strengthening and spasticity. Dr. Karel Bobath and Dr. Berta Bobath developed a theory in the 1940's suggesting that strengthening a spastic muscle would increase the contraction, thus increasing the spasticity [5]. Ross and Engsberg, on the other hand, discovered that there was no correlation between strength and spasticity [6]. To resolve the controversy related to resistance training and its relationship to the improvement of gait in children with spastic CP, and to synthesize a clear clinical decision to support future evidence-based practice, the authors of this paper chose to delve into a review of recent published research.

METHODS

The fundamental question of this review is, “Should resistance training be used as an intervention for the treatment of gait dysfunction in children with spastic cerebral palsy?” To determine the answer to this question using evidence-based practice, the authors of this paper began the search using EBSCO host. EBSCO host was accessed through Tennessee State University's library

electronic resource website (http://www.tnstate.edu/library/milcat/databases.htm). This is an all-encompassing database aggregator that provides links to multiple other medical databases, such as Medline and Pro Quest. The Academic Search Premier was chosen because it is the world's largest multi-disciplined academic database with more than 3,600 peer-reviewed articles dating back to 1975. This database is updated daily via EBSCO host. This search was performed between October of 2006 and December 2007.

Cerebral palsy and strength were chosen as keywords. The options of full text and peer-reviewed journals only were utilized. The expanded search option to search for similar keywords was used throughout the process. One-thousand three hundred seventy-five articles which discussed various aspects of cerebral palsy and strength were chosen for inclusion. Most of these articles discussed each keyword phrase independently of the other. The search was therefore expanded to view titles that encompassed both. The narrow results by subject option was chosen to evaluate other keywords, including coordination and children. There were several hundred articles available, so the decision was made to progress with more focused keywords.

Gait and spasticity were used to narrow the search down to 63 articles. The authors reviewed the research articles that most directly focused on the clinical question. Of the 63 articles found throughout this process, the most applicable and most empirical 15 were chosen. The resulting 15 articles were reviewed and rated to determine the strength of evidence using the Sackett Classification Method [22].

The search was continued utilizing the online Pediatric Physical Therapy Journal published by the Pediatric Section of the American Physical Therapy Association. After entering cerebral palsy and strength into the search box, 18 articles were accessed. The appropriateness and relevance of each article in addressing the clinical question were analyzed. Three articles were chosen and rated using the Sackett Classification Method to determine the strength of the empirical evidence.

Finally, an interview with Ms. Sandy Stevens, OTR at Tennessee State University, was conducted regarding her ongoing experiment on the topic of children with CP who are engaged in an aquatic rehabilitation program to improve strength and maintain functional activity throughout adulthood. It was concluded that the professional opinion obtained and the 19 articles selected would be sufficient in answering the research question based on the merit of research conducted within the studies. According to the criteria presented in the Sackett Classification, seven of the articles were rated as level 1, five as level 2, three as level 3, three as level 4, and one as level 5.

DISCUSSION

When determining the answer to the fundamental question, the authors of this paper had to first find the answers to a series of minor questions. Initially, it was essential to identify the impairments associated with ambulatory deficits in children with cerebral palsy. The question was asked, “Is weakness, in fact, an impairment that contributes to gait dysfunction in children with spastic CP?” According to Bartlett and Palisano, muscle strength is a primary impairment influencing motor abilities in children with CP [2]. After analyzing sixty articles, Damiano et. al. also concluded that weakness is a significant impairment in CP [4]. Eagleton et. al. found that through biomechanical and electromyographic analyses of gait “the primary limiting factor in ambulation for children with CP is muscle weakness” [3]. Evidence reveals that weakness of the lower extremities is an impairment limiting functional abilities in this population [7,8], thus decreasing the amount of weakness through strengthening activities could help improve ambulatory skills.

Because the research question is specific to children with spastic CP, the relationship between strength and spasticity also required attention. In the past, the use of resistance training on individuals with spasticity was not recommended. However, the theory behind this recommendation lacked scientific evidence for support [3,9]. Dr. Karel Bobath and Dr. Berta Bobath's theory of the 1940's was based on the assumption that a spastic muscle is a contracted muscle, thus strengthening an already contracted muscle would contribute to the contraction [5]. Although the Bobath theory provides a potentially viable contention, the authors of this paper turned to the evidence to establish a conclusion.

Following participation in a 10-week progressive strength training program performed by Andersson et. al., not one of the 17 subjects tested experienced a change in spasticity [1]. In another study by Fowler et al., 24 children with spastic CP demonstrated no change in spasticity following participation in a strengthening program [9]. Evidence reveals

that there is no relationship between spasticity and the strength of a muscle [1,6,9,10,11]. This may be because the two entities are controlled by separate neuronal pathways. Spasticity is an involuntary, reflexive movement of muscles. This phenomenon results because damage to the brain limits its ability to suppress the activity of the reflex loop at each spinal cord level [4,6]. Voluntary movement, however, is controlled by the conscious signals of the brain to specific musculature through the cortical spinal tract [4,6]. As a result, resistance training does not decrease the amount of spasticity, nor does it increase the amount of spasticity [1,6,9,10,11], thus deeming strength training harmless in its presence.

Finally, it needed to be determined if a strengthening program for children with spastic CP resulted in improvements in gait function. According to Andersson et. al., all participants declared that their walking ability had improved after participating in a 10-week progressive strength training program that focused on the lower extremities. The results showed significant increases in strength, gross motor function measure, and walking velocity [1].

All articles reviewed reported significant improvements in one or all of the factors associated with gait function [1,4,7,8,9,11,12,13,14,15,16,17,18]. A 6-week home-based strengthening program, performed by Dodd, et. al., resulted in improvements in ability to stand, jump, run, and climb stairs [18]. A study performed by Ketelaar et. al., found that a functional strengthening program provided significant improvements in overall walking ability for 55 children with CP ranging from ages 2-7 years [12]. A 6-week strengthening program by Brownlee et. al., specific to the quadriceps and hamstrings, was found to increase gait speeds and stride length [13]. Whether the strengthening program was a group circuit resistance program [14], an isometric, isotonic, or isokinetic program [9]; a program using weight machines, free weights, theraband, or body weight [3]; or an aquatic treadmill training course [7], the results were consistent. Every article reviewed rendered significant improvements in overall gait function in one or multiple variables related to ambulation [1,4,7,8,9,11,12,13,14,15,16,17,18]. Likewise, not one of the 19 articles resulted in adverse effects secondary to strengthening programs in children with spastic CP. The results strongly support the utilization of strengthening exercises to improve the gait pattern in children with spastic cerebral palsy.

CONCLUSION

Based on the outcomes of the evidence collected, these authors conclude that strength training should be used as an intervention for the treatment of gait dysfunction in children with spastic cerebral palsy. No disadvantageous consequences could be found in the literature related to the use of resistance training with spasticity. It was also evident that strength training can provide numerous other benefits for children with spastic CP [19], and the incorporation of resistance training for isolated muscle groups should be utilized in physical therapy protocols for this population [17].

With the analysis of the exercise programs used within the articles reviewed, the authors of this paper advocate a resistance training program for the lower extremities addressing the major muscle groups for improving ambulation. Hip flexors, hip extensors, hip abductors, quadriceps, hamstrings, dorsiflexors, and plantarflexors are the major muscle groups associated with gait function [19]. Hip flexors control hip extension at the end of stance phase and then contract to initiate swing phase while the hip extensors control the flexor moment at foot contact and then initiate hip extension. Hip abductors control the lateral pelvic shift during swing phase of the opposite leg and the quadriceps extends the knee during midstance. The hamstrings are responsible for forward swing of the leg during terminal swing phase, the dorsiflexors facilitate ground clearance and heel strike, and the plantarflexors are responsible for heel-off [20]. Although individuals with spastic CP often present with spastic musculature of the hip flexors and/or plantarflexors, the information gathered during this project justifies the decision to perform various resistance training techniques with the foundation that spasticity will not change and walking ability will improve when weakness is addressed.

Bottos, et. al. have reported that, “Despite concrete evidence refuting the disadvantages of strength training, it is still used so seldom that an astonishing number of individuals with CP are losing their ability to walk in early adulthood” [21]. Transforming conservative views on resistance training for children with CP will be a difficult challenge, but a necessity for professional growth and the provision of the most effective treatment to optimize and prolong ambulation in individuals with spastic CP.

ACKNOWLEDGEMENTS

Mr. Larry Green

Dr. Natalie R. Housel, PT, EdD, GCS

Mrs. Tiarra Liwig, PT

Mrs. Jennifer Saujon, PTA

References

1. Andersson C, Grooten W, Hellsten M, Kaping K, Mattsson E. Adults with cerebral palsy: walking ability after progressive strength training. Dev Med Child Neurol. 2003. 45(4):220-8.
2. Bartlett, D.J., Palisano, R.J. Physical Therapists' Perceptions of factors influencing the acquisition of motor abilities of children with cerebral palsy: Implication for clinical reasoning. Phys Ther. 2002. 82(3): 237-248.
3. Eagleton M, Iams A, McDowell J, Morrison R, Evans CL. The Effects of Strength Training on Gait in Adolescents with Cerebral Palsy. Pediatric Physical Therapy. 2004; 16:22-30.
4. Damiano DL, Dodd K, Taylor NF. Should we be testing and training muscle strength in cerebral palsy? Dev Med Child Neurol. 2002. 44: 68-72.
5. Bobath K. A Neurophysiological Basis for the Treatment of Cerebral Palsy. 2nd ed. London, England: William Heinimann Medical Books Ltd: 1980.
6. Ross SA, Engsberg JR. Relation between spasticity and strength in individuals with spastic diplegic cerebral palsy. Dev Med Child Neurol. 2002. 44: 148-157
7. Stevens S. Oral communication on October 4 2007. 3500 John A. Merritt Blvd., Nashville, TN 37209. sstevens@tnstate.edu.
8. Marques, J. Lower-Extremity Strength Profiles in Spastic Cerebral Palsy [Departments: Critical Reviews of Current Research]. Pediatric Physical Therapy. 2002. 14 (3). 161-162.
9. Fowler EG, Ho TW, Nwigwe AI, Dorey FJ. The Effects of Quadriceps Femoris Muscle Strengthening Exercises on Spasticity in Children with Cerebral Palsy. Phys Ther. 2001. 81: 1215-1223.
10. Ohata K, Tsuboyama T, Ichihashi N, Minami S. Measurement of Muscle Thickness as Quantitative Muscle Evaluation for Adults with Severe Cerebral Palsy. Phys Ther. 2006. 86(9): 1231-1239.
11. Damiano D. Activity, Activity, Activity: Rethinking Our Physical Therapy Approach to Cerebral Palsy. Phys Ther. 2006; 86:1534-1540.
12. Ketelaar M, Vermeer A, Hart H, Beek EP, et al. Effects of a Functional Therapy Program on Motor Abilities of Children with Spastic CP. Phys Ther. 2001. 81(9): 1534-1545.
13. Brownlee M, McFayden A, Morton J. The Effects of Progressive Resistance Training for Children with Cerebral Palsy. Clinical Rehabilitation. 2005.19:283-289.
14. Adams R, Blundell S, Dean C, Shepherd R. Functional strength training in cerebral palsy: a pilot study of a group circuit training class for children aged 4-8 years. Clinical Rehabilitation. 2003. 17:48-57.
15. Arnold AS, Delp SL. Computer modeling of gait abnormalities in cerebral palsy: application of treatment planning. Theoretical Issues in Ergonomics Science. 2005. 6(3-4): 305-312.
16. Pippenger W, Scalzitti D. What are the effects, if any, of lower-extremity strength training on gait in children with cerebral palsy? Phys Ther Washington. Sept 2004. 84:849-858.
17. Darrah J, Fan JSW, Chen LC, Nunweiler J, Watkins B. Review of the Effects of Progressive Resisted Muscle Strengthening in Children with Cerebral Palsy: A Clinical Consensus Exercise. Pediatric Physical Therapy. 1997; 9:12-17.
18. Dodd KJ, Taylor NF, Graham HK. A randomized clinical trial of strength training in young people with cerebral palsy. Dev Med Child Neurol. 2003. 45: 652-657.
19. Unger M, Faure M, and Frieg A. Strength training in adolescent learners with cerebral palsy: A Randomized Controlled Trial. Clinical Rehabilitation. 2006. 20: 469-477.
20. Kisner C, Colby LA. Therapeutic Exercise Foundations and Techniques. 4th ed. Philadelphia, PA; 2002.
21. Bottos M, Feliciangeli A, Sciuto L, Gericke C, Vianello A. Functional status of adults with cerebral palsy and implications for treatment of children. Dev Med Child Neurol. 2001; 43: 516-528.
22. Sackett DL. Oxford Centre for Evidence-Based Medicine Levels of Evidence. 2001. Available at: http://www.minervation.com/cebm2/docs/levels.html#levels. Accessed October 15, 2006.

Author Information

David A. Lehman, PT, PhD
Associate Professor, Physical Therapy, Tennessee State University

Amanda S. Garban, BS, SPT
Physical Therapy, Tennessee State University

Lauren E. Scott, BS, SPT
Physical Therapy, Tennessee State University

Candice S. Tant, BS, SPT
Physical Therapy, Tennessee State University

D. Collin White, BS, SPT
Physical Therapy, Tennessee State University