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Rehabilitation Interventions for Children With Cerebral Palsy: A Systematic Review

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Context: Cerebral palsy (CP) is a group of movement problems that do not worsen over time. They cause physical disability mainly in areas of body movement. It is caused by damage to the motor control centers of developing brain. Management of a child with CP to optimize functional abilities, typically includes the input of many disciplines, including occupational therapy (OT), physical therapy (PT) and orthotic treatment. The main aim of this review was to compare the effects of most common rehabilitation intervention on CP.
Evidence Acquisition: This systematic review was conducted on published papers that studied rehabilitation interventions approaches for children with CP. A literature search was performed using PubMed, SCOPUS and Google Scholar on papers published from January 1990 to October 2014.
Results: From 125 articles related to rehabilitation interventions for children with Cerebral palsy, 36 articles met the inclusion criteria.
Conclusions: The efficacy of rehabilitation interventions for children with CP is still inconclusive. Functional ability and social participation should be the main outcome measures in evaluating rehabilitation efficacy.

Keywords: Rehabilitation; Intervention; Cerebral Palsy

1. Context

Cerebral palsy (CP) is a static encephalopathy defined as a non-progressive disorder of posture and movement. It often accompanies epilepsy and abnormalities of speech, vision and intellect, resulted from a defect or lesion in the development course of brain (1). CP is a common disorder with an estimated prevalence of 2/1000 in the general population (2, 3). CP involves a group of permanent disorders in development of movement and posture, causing limitation in every day activity, which is because of non-progressive disorders during the fetal or infant brain development. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication and behavior, by epilepsy and secondary musculoskeletal problems (4). Because of significant limitations in activity, these individuals often require rehabilitation throughout their life (5, 6).

Previous reviews showed the effectiveness of rehabilitation interventions in children with CP concentrating on neurodevelopmental therapy (NDT) (7-9), strength training (10, 11), conductive education (12-14), various physical therapy (PT) interventions (15-18) or orthotic devices (19, 20) and occupational therapy (OT) (21). In the management of a child with CP, to improve his or her functional abilities, typically input of many disciplines should be comprehended, including OT, PT and orthotic treatment (22). Generally, the effectiveness and efficacy of therapeutic interventions for children with CP has been difficult to ascertain because of high-quality research absence (21). Siebes et al. demonstrated an improvement in the methodological quality of therapeutic intervention researches in the last decade (23).

Parents and clinicians evaluate motivation as the most effective personal characteristic that preordains functional and motor outcomes in children with CP (24, 25). Evidence from neuroplasticity literature identified motivation as a significant determinant of functional plasticity. Neural restructuring develops at the molecular and behavioral level and is influenced by factors such as development, the environment, disease and therapy (26). Clinicians can modify the sensorimotor environment using motivation to reinforce reorganization and improve rehabilitation outcomes by means of augmented engagement. Contrarily, insufficient motivation can restrict children from attaining their functional potential (27, 28).

Clinicians devise rehabilitation interventions to enhance cooperation and health outcomes in children with CP (29). Therapists, general practitioners and parents need a new information about widely used rehabilitation interventions effectiveness and outcomes for evidence based management of children with CP (7). The main goal of this review was to compare the effects of most common rehabilitation interventions in CP.

2. Evidence Acquisition

A systematic review was conducted on published papers studied rehabilitation interventions approaches for children with CP. A literature search was performed using PubMed, SCOPUS and Google Scholar on papers published from January 1990 to October 2014. Following Medical Subject Headings (MeSH) were used; cerebral palsy, occupational therapy, physical therapy, orthoses, orthosis and splint (Figure 1). All abstracts and full text English-language articles were studied. In addition, the reference lists of identified articles were scanned and related articles link on PubMed was used to find relevant articles. The titles and abstracts of articles identified by the initial search strategy were assessed independently by two of researchers for the following inclusion criteria: (1) population children with CP, (2) intervention (based on generally occupational therapy, physical therapy and orthoses) and (3) outcome measurements (type of measurement). When the title or abstract did not clearly indicate whether an article should be included, full-text article was obtained and read to determine if it met all the three inclusion criteria. For example, articles were excluded if intervention was used only on different techniques in intervention and mixed with other approaches rehabilitation. Differences were resolved by consensus.

3. Results

From 125 articles related to rehabilitation interventions for children with cerebral palsy, 36 articles met the inclusion criteria. Table 1 shows a summary of findings from the reviewed articles.

4. Conclusions

There was mediocre evidence that strength training had no effects on self-selected walking speed based on four trials (30-33) or on striding a length compared to no training based on two trials (32, 33). Inconsistent evidence was found on the strength training efficiency on gross motor function measured by GMFM compared to no training (30, 32). In an earlier review, strength training effect on walking speed and gross motor function studied regarding a few observational researches were opposite and positive, respectively (7, 11).

Children with CP aged 7 months to 18 years were included, as well as all CP types and severities. Authors' description of diagnosis was trusted in this review. None of the included studies reported a meaningful improvement in motor performance or resolution of signs characteristics of CP, indicating that the diagnosis of CP had been correct. In some trials, the heterogeneity was described by stratification successfully. The heterogeneity is a major

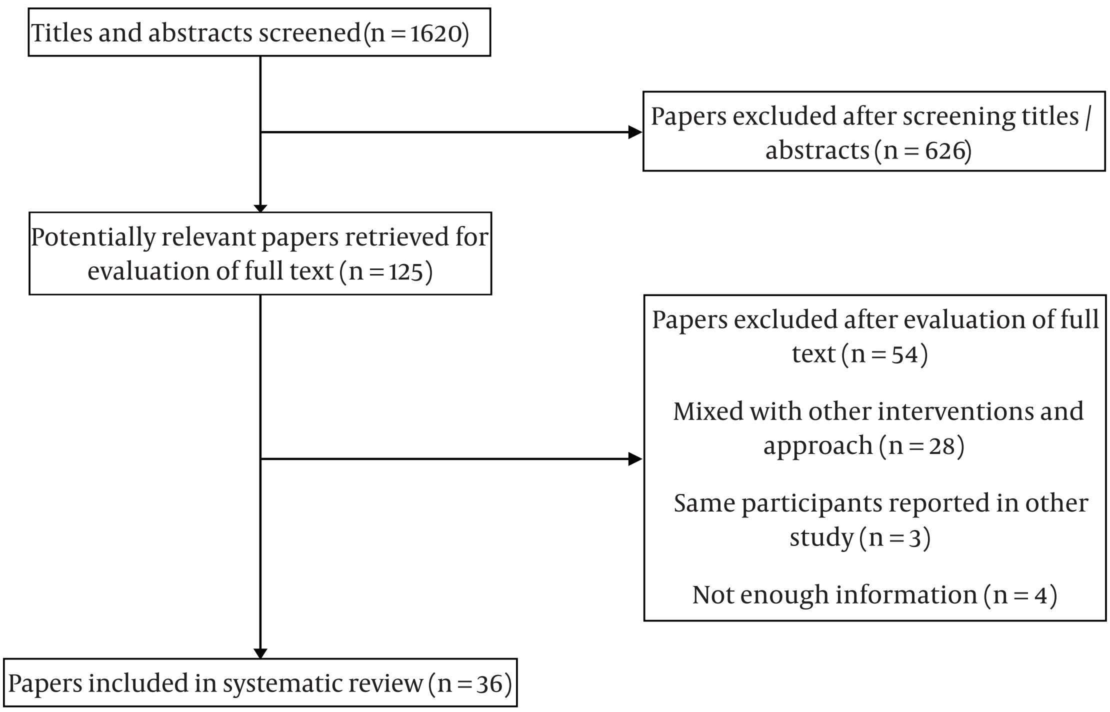

Figure 1. Diagram of Included Articles

challenge in research and furthermore when tried to apply the results to children with CP in clinical practice. The goals of interventions in a toddler with hemiplegia are thoroughly different than an older non-ambulant child with a specific learning disorder. It is important to precisely contemplate the inclusion criteria for different studies before clinical application of evidence (7).

Children in many trials continued their usual therapy, the content and intensity of which was not described. Therefore these additional therapies may have confounded the outcomes. Environmental factors, like parental support, home and leisure time activities, may have influenced children's functional abilities, which should be recorded and reported similarly for all intervention groups to provide the possibility of evaluating bias (7).

As stated by Cury et al. (75), orthoses are part of the daily practice for children with CP and offer benefits mainly in outdoor environments mobility. The author also stated that orthoses considerably improve gait quality in children with CP compared to a control group. The authors indicated that articulated orthosis should be used for patients who have better hip and knee control along with gaining a more functional gait pattern (76).

Wilson et al. (77) reported that an articulated orthosis provided a better transition between sitting and standing positions. For more complex tasks, greater range of motion in joints is required, which functions more efficiently when allowed to move freely. As a result, a rigid orthosis is more restricting for certain tasks and an articulated orthosis provides greater functional freedom for other tasks. Nonetheless, these biomechanical supremacies may not be made apparent in gait analyses. There is evidence encouraging the use of an articulated ankle foot orthosis (AFO) by children with CP because of the enhanced function when using this type of orthosis. Yet, other studies indicated the advantages of a rigid orthosis for children with greater disabilities involving spasticity and contracture (76).

These results made it difficult to determine which type of AFO is useful in each group of children. Clinicians should depend on their clinical experience and patient values to handle the clinical decision-making process in a way that the use of AFOs improves the gait in children with CP. They should also look for new studies that render valid and pertinent evidence to be a foundation to their clinical practice (78).

Another important matter is the fact that a lack of evidence does not always mean a lack of effectiveness. Especially, lack of control over confounding variables is often a dominant problem confining the studies to present evidence. Stretching can be effective in improving ROM in children with CP. Stretching should rather be retained for a minimum of 30 seconds (79).

There is inconsistent evidence regarding the effectiveness of electrical stimulation strength. Neuromuscular electrical stimulation (visual contraction, > 10mA) is desirable. Nonetheless, parents and children rated an important subjective feeling of improvement and a high feeling of contentment likewise (80, 81).

Strength training is very effective to improve muscle strength and in a lesser extend in improving gait and motor function. Resistance of 65-80% in one repetition maximum appears to be tolerated considerably by children. Effects seem to be lost almost quickly after stopping the program. Treadmill training is useful in improving gait and endurance in children with CP, depending on used modalities. With partial body weight support, treadmill training can be effective in very young children with CP. Endurance training is useful to improve aerobic endurance. Effects seem to last minimally as long as the training program itself. A training heart rate of 75% of the maximum heart rate seems to be well tolerated.

Massage improves the feeling of well-being in children with CP and their parents. Balance training is most favorably trained in a task-specific theme. Weight-bearing is effective in improving bone mineral density in children with CP (79). Moderate evidence of effectiveness was demonstrated for two intervention categories: effectiveness of upper extremity treatments on achieved goals and active supination, and of prehensile hand treatment and NDT twice a week on developmental status, and of constraint-induced therapy on amount and quality of hand use. Moderate evidence of ineffectiveness was found for strength training on walking speed and stride length. Inconsistent evidence was found for strength training on gross motor function. In other intervention categories, the evidence was limited due to poor methodological quality and statistically negligible results of studies (7).

Orthoses are only one of the several interventions used in compound health care modalities for children with various childhood disabilities including CP. Other issues to be considered in designing large trials are different models for delivering services and confounding effects of other medical and surgical interventions. To accomplish a successful randomization, allocation, and follow-up in a clinical trial, a universal process of prescription and management is definitely required (19).

RCT characteristics which evaluate large homogeneous groups on the efficacy of a homogeneous intervention are in contradiction with clinical practice, which might provide an explanation for the deficiencies of most studies included in this review. An objective of future efficacy studies should be using sufficiently homogeneous population. The criteria of sample size and homogeneity should both be met, and a pilot study might be required to demonstrate whether these criteria can be fulfilled in CP research. The large variability in OT treatment for children may justify 15 single-case studies identified in this review. Single-case studies using a repeated time-series design can resolve the variability problem, but single-case design studies were excluded from our review, because of the issues regarding generalizing evidence from these studies to a larger population of children with CP (21).

Table 1. A Summary of Findings From the Reviewed Articles

Author	Year	Title	Intervention	Outcome Measure
Physical Therapy				
Liao et al. (30)	2007	effectiveness of loaded sit-to-stand resistance exercise for children with mild spastic diplegia: a randomized clinical trial	home-based loaded sit-to-stand exercise, GMFM	Self-selected walking speed
Dodd et al. (31)	2003	a randomized clinical trial of strength training in young people with cerebral palsy	home-based strength training, GMFM	self-selected walking speed
Patikas et al. (32)	2006	effects of a postoperative strength-training program on the walking ability of children with cerebral palsy: a randomized controlled trial	Strength training, GMFM	walking speed, Stride length
Unger et al. (33)	2006	strength training in adolescent learners with cerebral palsy: a randomized controlled trial	circuit training	walking speed, Stride length
Occupational Therapy				
Law et al. (34)	1991	neurodevelopmental Therapy and Upper-Extremity Inhibitive Casting for Children with Cerebral Palsy	NDT, Cast	Peabody, QUEST
Law et al. (35)	1997	a comparison of intensive neurodevelopmental therapy plus casting and a regular occupational therapy program for children with cerebral palsy	NDT, Cast	Peabody, QUEST
Bumin and Kayihan (36)	2001	effectiveness of two different sensory-integration programs for children with spastic diplegic cerebral palsy	SPM training, Home program	physical ability test, SCMAT
Guidetti and Soderback (37)	2001	description of self-care training in occupational therapy: case studies of five Kenyan children with cerebral palsy	dressing and undressing during play outpatients	Klein-Bell scale
McConachie et al. (38)	2000	a randomized controlled trial of alternative modes of service provision to young children with cerebral palsy in Bangladesh	distance training, mother-child group, health advice	IBAS
Pope et al. (39)	1994	postural control in sitting the SAM system: evaluation of use over three years	SAM seating system	mobility (5 point scale)
Orthotic Treatment				
Blair et al. (40)	1995	a study of a dynamic proximal stability splint in the management of children with cerebral palsy	Lycra garment	gross and fine motor function
Edmondson et al. (41)	1990	how effective are Lycra suits in the management of children with cerebral palsy	Lycra garment	gross-motor skills, Balance, Fine motor function
Buckon et al. (42)	2004	Comparison of three ankle–foot orthosis configurations for children with spastic diplegia	rigid, Articulated and posterior leaf spring	GMFCS, gait analysis
Rethlefsen et al. (43)	1995	a comparison of the effects of fixed versus articulated ankle foot orthoses on gait in subjects with cerebral palsy	rigid and articulated AFO	gait analysis, gait parameters
Rethlefsen et al. (44)	1998	the effects of fixed versus articulated ankle foot orthoses on gait in subjects with cerebral palsy	rigid and articulated AFO	gait analysis, gait parameters
Radtka et al. (45)	2005	a comparison of gait with solid and hinged ankle-foot orthoses in children with spastic diplegic cerebral palsy	rigid and articulated AFO	gait analysis, gait parameters
Smiley et al. (46)	2002	a comparison of the effects of solid, articulated and posterior leaf-spring ankle-foot orthoses and shoes alone on gait and energy expenditure in children with spastic diplegic cerebral palsy	rigid, articulated and posterior leaf spring	gait analysis, gait parameters
Buckon et al. (47)	2001	comparison of three ankle-foot orthosis configurations for children with spastic hemiplegia	rigid, articulated and posterior leaf spring	gait analysis, gait parameters
Mossberg et al. (48)	1990	ankle-foot orthoses: effect on energy expenditure of gait in spastic diplegic children	conventional plastic AFO, Shoes	energy expenditure
Butler et al. (49)	1992	improvement in walking performance of children with cerebral palsy: preliminary results	fixed AFO, Shoes	kinetic and kinematic analysis
Ounpuu et al. (50)	1996	an evaluation of the posterior leaf spring orthosis using joint kinematics and kinetics	PLS	kinetic and kinematic analysis
Radtka et al. (51)	1997	a comparison of gait with solid, dynamic, and no ankle-foot orthoses in children with spastic cerebral palsy	solid and dynamic AFO	EMG

Hninsworth et al. (52)	1997	a preliminary evaluation of ankle orthoses in the management of children with cerebral palsy	hinged and solid AFO	ROM, kinetic and kinematic analysis
Carlson et al. (53)	1997	orthotic management of gait in spastic diplegia	Fixed AFO, SMO	active ankle ROM, kinetic and kinematic analysis
Abel et al. (54)	1998	gait assessment of fixed ankle-foot orthoses in children with spastic diplegia	Fixed AFO	kinetic and kinematic analysis
Brunner et al. (55)	1998	comparison of a stiff and a spring-type ankle-foot orthosis to improve gait in spastic hemiplegic children	rigid and spring AFO	kinetic and kinematic analysis
Rethlefsen et al. (56)	1999	the effects of fixed and articulated ankle-foot orthoses on gait patterns in subjects with cerebral palsy	fixed and articulated AFO	kinetic and kinematic analysis
Suzuki et al. (57)	1999	energy expenditure of diplegic ambulation using flexible plastic ankle foot orthoses	flexible plastic AFO	energy expenditure
Maltais et al. (58)	2001	use of orthoses lowers the O (2) cost of walking in children with spastic cerebral palsy	hinged AFO	energy expenditure, GMFM
Dursun et al. (59)	2002	ankle-foot orthoses: effect on gait in children with cerebral palsy	AFO	kinematic analysis
Romkes et al. (60)	2002	comparison of a dynamic and a hinged ankle-foot orthosis by gait analysis in patients with hemiplegic cerebral palsy	hinged and dynamic AFOs	kinetic and kinematic analysis
White et al. (61)	2002	clinically prescribed orthoses demonstrate an increase in velocity of gait in children with cerebral palsy: a retrospective study	solid and hinged AFO	kinematic analysis
Lam et al. (62)	2005	biomechanical and electromyographic evaluation of ankle foot orthosis and dynamic ankle foot orthosis in spastic cerebral palsy	conventional and dynamic AFO	EMG, kinetic analysis
Evans et al. (63)	1994	the effectiveness of orthoses for children with cerebral palsy	AFO with Hybrid hinged	GMFM, ROM
Crenshaw et al. (64)	2000	the efficacy of tone-reducing features in orthotics on the gait of children with spastic diplegic cerebral palsy	hinged AFO, SMO	activity-walking
Ferdjallah et al. (65)	2000	functional assessment of AFOs for children with cerebral palsy using postural stability, gait analysis and GMFM	hinged AFO, SMO	activity-walking
Desloovere et al. (66)	1999	effects of ankle foot orthoses on the gait of cerebral palsy children	rigid AFO, PLS	activity-walking
Buckon et al. (67)	1999	a preliminary comparison of the effect of solid, hinged and posterior leaf spring AFOs on the gait of children with spastic hemiplegia and diplegia	hinged AFO, PLS	activity-walking
Sienko-Thomas et al. (68)	2000	sagittal plane kinematics of the hip, knee and ankle in children with hemiplegia during stair ascent and descent using three different ankle foot orthosis (AFO) configurations	rigid and Hinged AFO, PLS	activity-stairs
Von Wendt et al. (69)	1995	assessment of dynamic orthoses with the macreflex® locomotion analysis system in children with spastic diplegia and hemiplegia	DAFO, SMO	activity-walking
Haideri et al. (70)	1995	the effects of solid and articulating ankle foot orthoses during sit-to-stand in young children with spastic diplegia	rigid and Hinged AFO	activity-sit- to-stand
Romskes et al. (71)	2000	evaluation of the Dynamic AFO (Nancy Hilton) through gait analysis in patients with cerebral palsy	rigid AFO, SMO	activity-walking
Burtner et al. (72)	1999	stance balance control with orthoses in a group of children with spastic cerebral palsy	rigid AFO, spiral-graphite	activity-standing
Abel et al. (54)	1998	gait assessment of fixed ankle-foot orthoses in children with spastic diplegia	rigid AFO	Balance
Orendurff et al. (73)	1998	predictors of stride length barefoot and with ankle foot orthoses in children with cerebral palsy	rigid AFO	activity-walking
Matthews (74)	2000	articulating ankle foot orthoses incorporating neurophysiological footplate rectifications: A case study	hinged AFO	activity-walking

Another reason for indeterminate findings could be chosen outcome measures. The means used may have been insensitive to the subtle, but important motor progress exhibited in children with CP. Moreover, relevant gains in non-motor areas, such as emotional status, parent/child interaction, language development and cognitive development, might have been expected, but were evaluated scarcely (82). The main objectives of OT are to boost functional abilities and improve social participation and well-being. Although we were able to find a reasonable number of studies, inconsistent findings regarding the efficacy of OT for children with CP demonstrate difficulties in efficacy research in OT for children with CP. Future investigations should majorly consider methodological issues such as homogeneity, sample size and outcome measures.

The efficacy of rehabilitation practice for children with CP is still inconclusive. Functional ability and social participation should be the main outcome measures in evaluating rehabilitation efficacy. In future efficacy studies, a great deal of attention should be paid to methodological quality issues.

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