

Review Article

Effects of strength training on mobility in adults with cerebral palsy: A systematic review

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Abstract

Background: Many adults with cerebral palsy report experiencing early-onset decline in mobility and independence. The role of strength training to combat this is not well understood.

Objective/hypothesis: To examine the effects of strength-training interventions on muscle strength and functional outcomes for adults with CP using the ICF framework.

Methods: A systematic review was conducted following standardized guidelines and using key words including: *adults, cerebral palsy* in combination with *resistance or strength training*, and *ambulation and function related key words*. Selection criteria included: (a) adults (mean age 18+ years) with CP, (b) strength training intervention, and (c) at least one activity or participation outcome measure. 26 retrieved articles were retained for full review. Data on strength training protocols were extracted and compared to national guidelines. Outcome measures were classified within ICF domains.

Results: Six articles met the inclusion criteria. These articles were of high research quality and consistent with recommended training protocols for adults with CP. Positive gains in muscle strength were reported across studies. Changes within the activity ICF dimension were inconsistent, with 2 of the 6 studies observing increases in self-selected walking speed.

Conclusions: Findings indicate training benefits for adults with CP. However, a small sample ($n = 111$ across all included studies) and the absence of extended training regimens and follow-up hindered conclusive results. High consistency in training protocols and outcome measures allowed for critical discussion on key research questions regarding the impact of strength training and subsequent gains in function within ICF domains. © 2016 Elsevier Inc. All rights reserved.

Keywords: Cerebral palsy; Rehabilitation; Resistance training; Walking

Cerebral Palsy (CP) is the highest occurring physical disability, present in 1 in every 323 individuals.¹ The hallmark characteristic of CP is disordered motor control resulting in activity limitations.² CP is attributed to a lesion in the developing brain that can present as difficulties or delays in postural or motor milestones and an abnormal neurological examination.² Despite the non-progressive nature of the

disorder, individuals with CP report experiencing a drastic decline in gross motor function as they age, ultimately resulting in a loss or decrease of independence.^{3–6} Adults with CP recall a marked decline in their physical function from early childhood (about 10 years of age) to adulthood (about 60 years), with the majority of individuals experiencing a dramatic decline before the age of 35.^{4–8} In a 5–15 year period after reaching adolescents or early adulthood, previous reports have consistently found adults with CP to have notable mobility declines.^{4–6} At present, the underlying mechanisms responsible for this decline in physical function and mobility are not well understood. It remains, however, that effective management strategies are needed to offset expected functional decline and promote optimal health outcomes for adults with CP.

Muscle weakness in individuals with CP is a strong predictor of overall gross motor function and individual levels of ambulatory independence.^{9,10} This has resulted in increased attention on muscle strength as a contributor to

Abbreviations: ACSM, American College of Sports Medicine; AACPD, American Academy for Cerebral Palsy and Developmental Medicine; CP, cerebral palsy; ICF, International Classification of Functioning, Disability and Health; NSCA, National Strength and Conditioning Association; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

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activity limitations and functional decline.^{9,11} In response, clinical goals have included resistance strength training programs in CP management plans.^{11–13} To date, empirical evidence has shown promising improvements in muscle strength for individuals, primarily children, with CP following individualized resistance training interventions.^{14,15} The effects of this intervention strategy for this population have been synthesized in several reviews.^{14–16} In 1997, Darrah, Fan, Chen, Nuweiler and Watkins found a total of seven articles all reporting positive effects of strength training for children and young adults (6–26 years) with CP.¹⁶ Unfortunately, generalization of these findings was cautioned in part due to the poor quality of reviewed articles, small sample sizes, and inconsistencies in classifying symptom severity and program protocols.¹⁶ A later review by Dodd, Taylor and Damino in 2002 aimed to provide an updated review of strength training benefits for individuals of all ages with CP.¹⁵ Eight of the 11 studies reviewed indicated positive gains in muscle strength and gross motor function following strength training programs. However, only one study was a randomized control trial and only one study included individuals above the age of 20 years. In 2005, a broad review of progressive strength training in clinical populations still only contained two studies focusing on the benefits for adults with CP.¹³ A 2014 meta-analysis¹⁴ revealed moderate to large effect sizes for strength training interventions on strength and activity outcomes among children with CP. Notably, these reviews consistently identified adults with CP as an underrepresented group within the strength training literature and a need for more rigorous studies focused on the appropriateness of including strength training in CP management programs for various age groups.

Furthermore, the absence of activity and mobility outcome measures and the restricted age range of studies (e.g. children to young adult), in past reviews make it challenging to assess the extent to which strength training can serve as a viable strategy for offsetting functional decline that may occur during the transition into adulthood. The early and rapid decline in function among adults with CP makes it imperative to expand this type of research to adult populations. To effectively inform clinical management of known gross motor function and mobility decline experienced by this population, an updated review of the literature, targeting adult populations (aged 18+ years), is warranted.

Discussion surrounding the theoretical relationships between gains in strength, following strength training programs, and gains in gross motor function and mobility is most appropriately framed using the *International Classification of Functioning, Disability and Health* (ICF).^{16,17} There is an emerging body of literature integrating existing knowledge on the dynamic pathways between factors of strength, mobility and independence in daily living with the ICF framework (e.g. Kim and Park,⁹ Rosenbaum and Stewart¹⁷). In solidarity with this effort, the purpose of this review is to systematically examine current literature on strength training programs for adults with CP, an underrepresented population,

and the subsequent changes in muscle strength, activity and participation, using the ICF framework.

ICF framework

The ICF framework, in the context of this review, models a theoretical multidirectional relationship between body structure and function, activity and participation, and the overall well-being of an individual.¹⁸ For individuals with CP, muscle weakness aligns with the *body-function and structure* dimension of health, and gross motor function and mobility fall within the *activity* dimension.¹⁷ The dynamic interaction between these factors is posited to facilitate independence in daily activities and engagement within the community (i.e. *participation*).

Methods

This review aimed to systematically examine the extent to which progressive strength training impacts muscle strength, functional independence and activity limitations among adults with CP. Standardized guidelines for systematic reviews by *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* (PRISMA)¹⁹ and reviews in rehabilitation by Dijkers, Bushnik, Heinemann, et al²⁰ were followed. Electronic searches of the following databases were conducted in February 2014 (and replicated in November 2015): MEDLINE, PUBMED, Web of Science, and Academic Search Premier. Search terms included *cerebral palsy and adults* in combination with *resistance, exercise, strength training, and ambulation, mobility, walking, performance, function, activity or participation*. Relevant truncation and wildcard symbols were used when accepted by search engines to broaden searches (e.g. an asterisks [*] would be placed on function* and would allow for the results of function, functional, and functioning). Titles and abstracts were scanned for keywords, with all ambiguous titles being retained for further evaluation (i.e. ‘Training in individuals with cerebral palsy’²¹). A secondary search was conducted of the first 10–15 pages of Google Scholar search results (using the same key search terms listed above and again with targeted key word combinations), and the reference lists from each relevant study.

Inclusion and exclusion criterion

Articles were retained for further evaluation if they met all of the following criteria: (a) the target population included adults, with a mean age of 18 years and older, with CP, (b) a strength training or progressive resistance training intervention/program was administered, and (c) functional activity or participation outcomes were measured. Studies were excluded if the primary intervention was not a strength or progressive resistance training program (i.e. aquatic, treadmill, cycling programs, cardiovascular training). The criteria for functional

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