REVIEW ARTICLE

# A Systematic Review of the Effectiveness of Strength-Training Programs for People With Cerebral Palsy

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ABSTRACT. Dodd KJ, Taylor NF, Damiano DL. A systematic review of the effectiveness of strength-training programs for people with cerebral palsy. Arch Phys Med Rehabil 2002;83:1157-64.

**Objective:** To determine whether strength training is beneficial for people with cerebral palsy (CP).

**Data Sources:** We used electronic databases to find trials conducted from 1966 though 2000; key words used in our search were *cerebral palsy* combined with *exercise*, *strength*, and *physical training*. We supplemented this search with citation tracking.

**Study Selection:** To be selected for detailed review, reports found in the initial search were assessed by 2 independent reviewers and had to meet the following criteria: (1) population (people with CP), (2) intervention (strength training or a progressive resistance exercise program), and (3) outcomes (changes in strength, activity, or participation). Of 989 articles initially identified, 23 were selected for detailed review.

**Data Extraction:** Empirical studies were rated for methodologic rigor with the PEDro Scale, and studies with a PEDro score of less than 3 were excluded. Review articles were evaluated for quality with the National Health Service Centre for Reviews and Dissemination form.

**Data Synthesis:** Of the 23 selected articles, 11 studies (10 empirical, 1 review) met the criteria for quality and were included. Only 1 randomized controlled trial was identified. With respect to impairment, 8 of the 10 empirical studies reported strength increases as a result of a strength-training program, with effect sizes ranging from $d$ equal to 1.16 (95% confidence interval, .11–2.21) to $d$ equal to 5.27 (95% CI, 4.69–5.05). Two studies reported improvements in activity, and 1 study reported improvement in self-perception. No negative effects, such as reduced range of motion or spasticity, were reported. There was insufficient evidence from which to draw conclusions about the effects of environmental and personal contextual factors.

**Conclusions:** The trials suggest that training can increase strength and may improve motor activity in people with CP without adverse effects. More rigorous studies are needed that have a greater focus on changes in activity and participation and that consider contextual factors.

**Key Words:** Cerebral palsy; Exercise therapy; Muscle weakness; Rehabilitation; Review literature.



CEREBRAL PALSY (CP) IS A CHRONIC neurologic disorder caused by a static lesion to the immature brain that is characterized by deficits in movement and postural control. Because of impairments such as weakness, spasticity, and incoordination, many people with CP have difficulty with activities such as propelling their wheelchairs, walking independently, negotiating steps, and running or navigating safely over uneven terrain.[1] Improving one's ability to walk or to perform other functional activities are often the primary therapeutic goals for people with CP.[2]

Medical practitioners and physical therapists need to know about the effectiveness of treatment techniques to make clinical decisions about patient care and use of limited therapy resources for people with CP. Evaluation and synthesis of the literature can provide this information. In recent years, strength-training programs have been advocated as 1 approach to maximizing function in people with CP.[3] Only 1 systematic review[4] has been published that examined the effects of strengthening in this population. Although this review synthesized the literature and provided useful insights, reports were not excluded on the basis of poor methodologic quality. Also, several potentially relevant trials have been conducted since the review was published. Therefore, this earlier review may not provide a sufficiently accurate and current assessment of the effectiveness of strength training for people with CP.

The purpose of our review was to determine whether strength training produces beneficial outcomes for people with CP. The positive and negative outcomes of strengthening were considered by using the *International Classification of Functioning, Disability and Health*[5] (ICF) framework for the description of health. In this framework, a person's disability can be considered in terms of impairments, activity limitations, and participation restrictions. According to the ICF definitions,[5] impairments are deviations or losses in body function or structure, activity limitations are difficulties in executing tasks or actions, and participation restrictions are problems with involvement in life situations. A person's functioning and disability is considered as a dynamic interaction between the health condition (in this case, CP) and contextual factors such as the environment.

## METHOD

### Study Identification and Selection

Electronic databases (MEDLINE, PubMed, EMBASE, CINAHL, Sports Discus, DARE, PsychInfo, ERIC, AusportMed, AMI, Cochrane, PEDro) were searched back to the earliest available time (1966) by using the following keywords: *cerebral palsy*, in combination with *exercise*, *strength*, and *physical training*. The search was limited to articles written in English. In addition, the reference lists of identified articles were scanned and the related articles link on PubMed was used to identify relevant articles.

The titles and abstracts of articles identified by the initial search strategy were assessed independently by 2 of us (KJD, NFT) for the following inclusion criteria: (1) population (adults or children with CP), (2) intervention (strength training or

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progressive resistance exercise program), and (3) outcome (measurement of change in strength, activity [function], or participation).

When the title or abstract did not clearly indicate whether an article should be included, the complete article was obtained and read to determine if it met all 3 inclusion criteria. For example, articles were excluded if strength was used only as an outcome measure for some other intervention such as hydrotherapy or hippotherapy. Differences were resolved by consensus.

### Quality Assessment

Empirical studies that met inclusion criteria were rated for methodologic quality with the PEDro Scale, based on the Delphi list described by Verhagen et al.[6] With the PEDro Scale, the following indicators of methodologic rigor were scored independently as either absent or present by 2 of us (KJD, NFT): (1) specification of eligibility criteria, (2) random allocation, (3) concealed allocation, (4) prognostic similarity at baseline, (5) subject blinding, (6) therapist blinding, (7) assessor blinding, (8) greater than 85% follow-up for at least 1 key outcome, (9) intention-to-treat analysis, (10) between-group statistical analysis for at least 1 key outcome, and (11) point estimates of variability provided for at least 1 key outcome. Interobserver agreement was calculated by using the weighted $\kappa$ statistic. Kappa measures observed and expected disagreement. Quadratic weights were used to rate the amount of disagreement between the 2 reviewers' final PEDro scores. According to the PEDro guidelines, criteria 2 through 11 are used for scoring purposes so that a score from 0 to 10 can be obtained.[7] The PEDro Scale has shown moderate levels of interrater reliability (intraclass correlation coefficient=.54; 95% confidence interval [CI], .39–.71).[8] To improve the reliability of this scale, any disagreements between the 2 reviewers were resolved by discussion until a consensus was reached. Empirical studies with low methodologic quality (a PEDro score $<3$) were excluded. Articles were also excluded if relevant data on the review question were repeated in another included article. The more comprehensive report was retained when this occurred.

Review articles were evaluated for quality with the National Health Service (NHS) Centre for Reviews and Dissemination form.[9] Review articles were included if at least 1 of the following NHS inclusion criteria were met: (1) sources of primary studies were identified, (2) the process used for selecting studies for detailed review was reported, and (3) criteria for assessing the quality of studies were detailed. Also, a review article must have been based on at least 5 key articles.

### Data Extraction

Data from the included empirical studies were summarized on a standardized form described by Darrah et al[4] that included the following headings: objectives, design, subjects, treatment, outcome measures used, results, conclusions, and other comments. Data from the review articles were summarized on the NHS form. That form includes items on methodologic quality and also summarizes the objectives of the review, the interventions investigated, the participants in the review, the outcomes measured, how studies were combined, how differences between studies were investigated, the results of the review, and the authors' conclusions.[9] From these summary forms, data were extracted about impairment, activity limitation, participation restriction, and contextual factors.[5] The contextual factors of particular interest were (1) whether the programs were administered in groups or to individuals; (2) whether the program was administered in a community, laboratory, or clinical environment; and (3) whether the cognitive function of the participants was considered.

### Data Analysis

Effect sizes with 95% CIs were calculated to allow comparison between the outcome measurements of the selected studies. Initial inspection of the empirical studies suggested that most were of a repeated-measures design without a control group. For this reason, the effect size was calculated by subtracting the posttreatment mean from the pretreatment mean and dividing by the standard deviation (SD) of the difference scores.[10] Because the SD of the difference scores cannot be calculated without access to the raw data, an approximation can be made by relating the SD of the difference scores to the correlation between the 2 sets of data.

Estimates of the reliability between pre- and posttest strength measurements were obtained from the articles that provided sufficient raw data. Estimates of reliability from these articles were $r$ equal to .91,[11] $r$ equal to .99,[12] and $r$ equal to .93.[13] When calculating the effect size of studies with insufficient data, a correlation of $r$ equal to .91 was used as a conservative estimate of pre–posttest reliability.

In many systematic reviews, a meta-analysis is performed, statistically combining the results of the various studies into a single estimated effect size. However, meta-analysis has been described specifically for randomized controlled trials (RCTs). In reviews such as this, which consist mostly of observational studies, the use of meta-analysis is generally not recommended.[14]

## RESULTS

Initial searching of electronic databases and manual searching of reference lists identified 989 articles. Of that number, 23 met the inclusion criteria; 18 articles reported the results of empirical studies and 5 were review articles. The interobserver reliability of assessing the methodologic quality of the empirical articles was $\kappa$ equal to .88, with disagreements in the PEDro score for 3 of the 18 articles. Five of the empirical articles were excluded because of low methodologic quality, with PEDro scores of less than 3[15-19]; 2 articles[20,21] were excluded because the data included in them was reported in other selected articles, and 1 article[22] was excluded because correlation was used as the outcome measurement. Of the 5 review articles, one[23] was excluded because the study inclusion strategy and criteria was not specified, and three[24-26] were excluded because they reported insufficient literature ($<5$ key articles) and also because they did not report study inclusion criteria.

Table 1 summarizes the findings of the 10 empirical studies.[11,12,27-34] No article scored more than 6 out of 10 on the PEDro Scale, and the median score was 4 (interquartile range, 3–5). Only 1 selected article[32] was an RCT. Therefore, none of the 9 other selected studies could fulfill criteria related to RCTs (eg, group allocation and blinding) as detailed in PEDro criteria 2 through 6. Most of the studies fulfilled PEDro criteria 8 through 11, indicating that most subjects undertook the designated strength-training program and that their outcome measures were reported, along with statistical comparisons of both point measures and measures of variability.

The only review article included in this systematic review was that of Darrah et al,[4] in which they evaluated the effects of progressive resistance exercise on children with CP. After a search of databases and reference lists, 7 articles were included in their review. Methodologic rigor was assessed according to Sackett's levels of evidence.[35] One article[32] was rated by Darrah[4] as level I evidence (a randomized controlled design),

**Table 1: Summary of 10 Empirical Studies**

| Study | PEDro Score | Age (y) | CP Class | Severity | Sample Size | Target Muscle Group | Program Details | Resistance | Impairment Outcome | Activity Outcome | Other Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Damiano and Abel[27] | 5 | 6–12 | Spastic D and H | Ambulatory, 6 required gait device | 11 | Lower limbs | Free-weights; 4 sets 5 reps, 3/wk for 6wk | 65% of maximum isotonic strength | Mean isometric maximal contraction | GMFM (total, section E); EEI; walking speed | Cadence, SL, stance, and DS |
| Damiano et al[28] | 5 | 6–14 | Spastic D | Ambulatory, 3 required gait devices | 14 | Quadriceps | Free weights; 4 sets 5 reps, 3/wk for 6wk | As above | Maximum isometric contraction | | |
| Darrah et al[29] | 4 | 11–20 | Spastic H, D, and Q, ataxic, dystonic | Ambulatory, 4 required gait devices | 23 | Upper and lower limbs | Free and fixed weights, aerobics; 1 set 6 reps, 3/wk for 10wk | 6RM | Maximum isometric contraction; ROM | EEI | Heart rate; perceived competence |
| Healy[12] | 4 | 8–6 | Spastic type | Not specified | 5 | Quadriceps | Isometric and isokinetic pulley weights; 3 sets 10 reps, 3/wk for 8wk | 10RM | Maximum voluntary contraction; knee ROM | | |
| Lockwood[30] | 3 | 12–47 | Spastic H | CP-ISRA class 7 or 8 | 6 | Upper limb: triceps, biceps | Isokinetic dynamometer; 3 sets 3 reps at 3 different velocities, 3/wk for 10wk | 3RM | Peak and average torque; grip strength | | Bimanual mvt efficiency; arm tracking; upper-arm girth |
| MacPhail and Kramer[31] | 4 | 12–20 | Spastic Q, D, and H | Ambulatory without gait devices | 17 | Quadriceps, hamstrings | Isokinetic, concentric and eccentric; 3 sets 5 reps, 3/wk for 8wk | 5RM | Peak torque and work; spasticity | GMFM (sections D, E); EEI; walking speed | |
| McCubbin and Shasby[32] | 6 | 10–20 | Spastic (24), mixed (4), athetoid (2) | Mixed (NASCP) | 30 | Triceps | Isokinetic, concentric and eccentric; 3 sets 10 reps, 3/wk for 6wk | 10 reps at maximum speed | Rate of torque development; movement time | | |
| O'Connell and Barnhart[33] | 4 | 7–14 | Spastic Q, D, and ataxic | Nonambulatory | 3 CP; 3 SB | Upper limb | Free weights, 3 sets 6 reps, 3/wk for 9wk | 6RM | Change in weight over 6RM | Distance travelled in WC in 12min; WC speed over 50m | |
| Toner et al[11] | 3 | 4–7 | Spastic H | Ambulatory without devices | 5 CP; 1 idiopathic toe walker | Dorsiflexors | Isokinetic, concentric, and eccentric; 7/wk for 6wk | 50% of 1RM | Peak torque; ankle ROM | | Dynamic tapping |
| Tweedy[13] | 3 | 10–18 | Spastic D | CP-ISRA classes 5 and 6 | 12 | Quadriceps | Concentric and eccentric program; 3/wk for 10wk | Variable, program cycled weekly | Peak torque; knee ROM; spasticity | | |

Abbreviations: D, diplegic; H, hemiplegic; EEI, Energy Expenditure Index; SL, stride length; DS, double support; Q, quadriplegic; RM, repetition maximum; ROM, range of motion; CP-ISRA, Cerebral Palsy International Sport and Recreation Association Classification System (8 levels); mvt, movement; NASCP, National Association of Sport for Cerebral Palsy Classification System (8 levels); SB, spina bifida; WC, wheelchair.

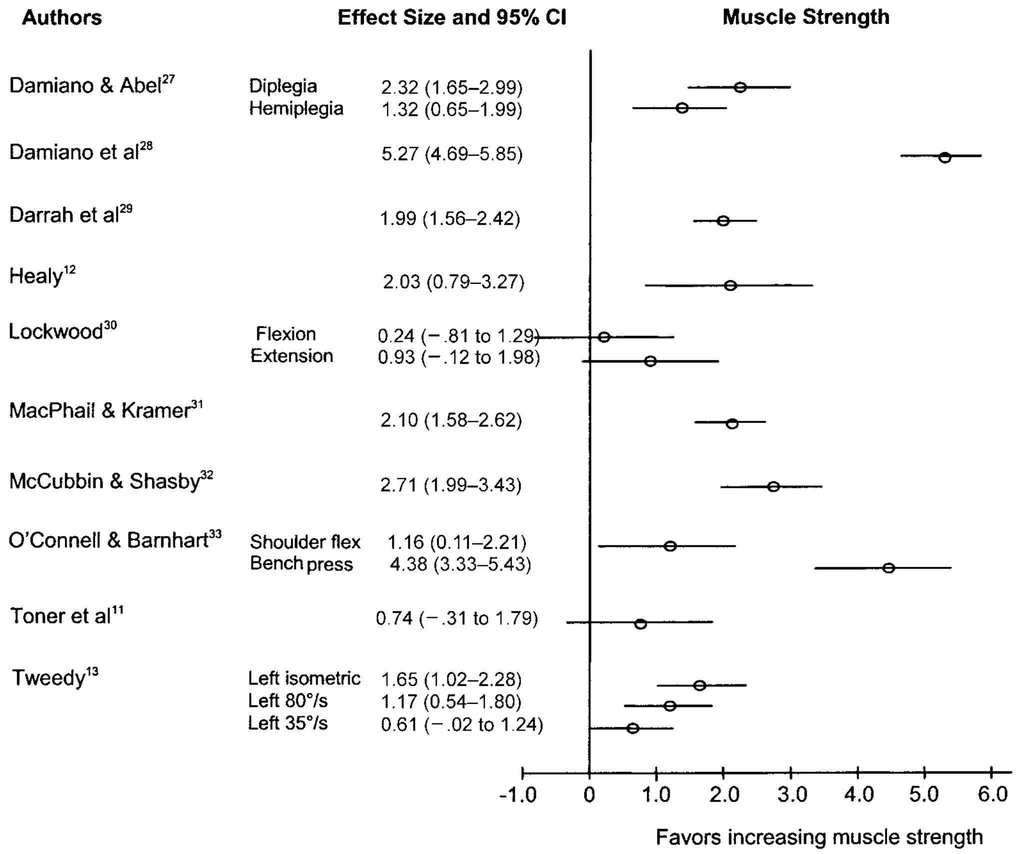


**Fig 1. Individual effect sizes for muscle strengthening.**

whereas the remaining 6 articles[12,15,16,21,28,31] were rated as level V evidence (case series without concurrent or historical controls). The Darrah review concluded that there was a low level of evidence that supported the benefits of strengthening exercises in children with CP. All studies they reviewed reported positive results on strength increases and none reported negative effects (eg, an increase in muscle spasticity). They noted that the relation between strength gains and improvement in function remained unclear. Four articles[12,28,31,32] included in Darrah's review were also selected for this review.

## Impairment

Figure 1 shows the individual effect sizes for strength changes in people with CP as a result of a strength-training program. Eight of the 10 selected studies[12,13,27-29,31-33] reported significant increases in strength. Among the studies that reported positive strength-training effects, considerable variation (heterogeneity) was noted in the effect size, ranging from 1.16 to 5.27. Power analysis of the 2 studies that did not report positive strength increases demonstrated power of less than 0.8. Toner et al[11] reported that power equaled .44; Lockwood[30] reported that power equaled .63 for knee flexion and was less than .15 for knee extension.

Only 2 of the selected articles[13,31] measured muscle spasticity. These articles reported results that inferred either no change or a reduction in spasticity after a strengthening program. Tweedy[13] measured the resistance to passive knee motion with an isokinetic dynamometer and found that the resistance to passive movement was significantly reduced at 60°/s but unchanged at other speeds. MacPhail and Kramer[31] measured spasticity of the quadriceps and hamstrings muscles with the Modified Ashworth Scale and found no significant change after training. However, the number of subjects with scores $\geq$1 for the 2 muscle groups was reduced from 16 to 4 after training, which suggests a trend toward reduction in muscle spasticity.

Four of the selected articles[11-13,29] measured range of motion (ROM). None reported a loss of ROM for people with CP who participated in a strengthening program. In fact, 3 studies reported significant increases in ROM after completion of a strengthening program at the knee[12,13] and ankle.[11] Another study[29] that summed arm and leg flexibility into a single score did not find any significant changes after strength training.

That same study[29] measured the psychologic impairment of self-concept. Darrah et al[29] applied the Self-Perception Profile for Adolescents[34] and found an improvement in the subscale of physical appearance ($P$=.006). This subscale measures the degree to which an adolescent is happy with the way he/she looks. Results on the same subscale of the Self-Perception Profile for Children (age range, <12y) approached significance, but the small number of children (n=4) meant that power to detect a difference was low in this group.

## Activity Restriction

Figure 2 shows the individual effect sizes for the effect of a strength-training program on the activity or function of people with CP. Only 4[27,29,31,33] of the 10 selected studies measured the effects of a strength-training program on activity restriction. In general, the effect sizes for activity appear smaller than the effect sizes for strength and impairment. The largest effect size for activity was 1.22, and only 3 of the 7 pre–posttest comparisons reached statistical significance. There were no

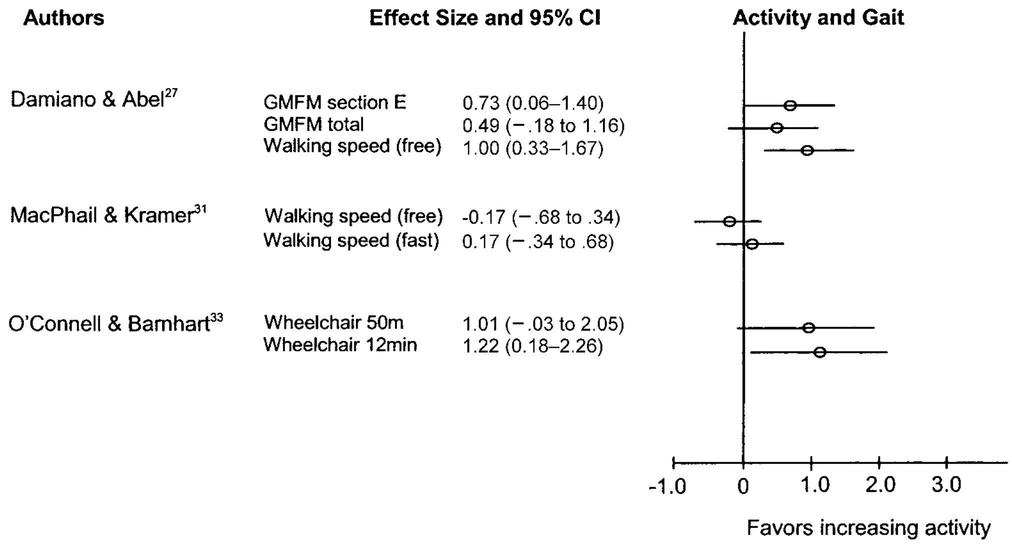


**Fig 2. Individual effect sizes for activity and gait.**

negative effects on activity reported from the strength-training programs.

Damiano and Abel[27] found a significant increase in the section of the Gross Motor Function Measure[36] (GMFM) that relates to walking, running, and jumping (dimension E). Similarly, MacPhail and Kramer[31] found that a significant number of subjects showed improvement in dimensions D (standing) and E of the GMFM after a strength-training program. An effect size could not be calculated from MacPhail and Kramer's GMFM data because the data were reported as dichotomous.

The effects of a strength-training program on measures of mobility were variable. Damiano and Abel[27] found a significant increase in walking speed after a strength-training program that targeted the weakest leg muscles, whereas MacPhail and Kramer[31] detected no change in walking speed after their subjects completed a program that strengthened the quadriceps and hamstrings. Also, there were no significant changes in walking efficiency as measured by the Energy Expenditure Index.[27,29,31] In terms of wheelchair mobility, O'Connell and Barnhart[33] found a significant improvement in the endurance-based, 12-minute wheelchair test after their training program. Although they did not detect a significant improvement in the 50-m wheelchair dash, the obtained effect size (1.01) for this variable suggests that the small sample size (n=6) may have adversely affected the power of this comparison.

### Participation Limitation

None of the 10 articles measured the effect of a strengthening program on participation limitation. However, Lockwood[30] and Darrah et al[29] have reported anecdotal examples of individuals who increased their participation in school and recreation after undertaking a strengthening program.

### Contextual Factors

Six of the exercise programs were administered to individuals[11,27,28,31-33]; one was a group program,[29] whereas the remainder of the studies did not specify this environmental factor. Both nonsignificant and positive results were reported for outcomes administered to individuals, whereas the only group study[29] reported positive effects.

Three of the studies[11,27,28] implemented a mixture of home- and clinic-based exercises. One program was conducted in a community gymnasium.[29] Again, both nonsignificant and positive results were found for the mixed programs, and positive effects were reported for the community-based program. Six of the studies did not provide details about the physical setting of their programs.

With regard to the personal factor of cognition, 4 of the articles[11,13,29,31] excluded participants who had severe cognitive impairment. Details were not provided about the cognition of participants in the remaining articles. None of the articles reported the inclusion of participants with significant cognitive impairment.

## DISCUSSION

Of the 10 empirical studies included in this review, only 1[32] was an RCT. The other 9 were observational studies that used a repeated-measures, single-group design (table 1). Six of the observational studies[12,27,28,30,32,33] had no control data with which to evaluate the effects of strengthening on people with CP, making it difficult to ascribe outcomes to the effects of intervention.

Three of the observational studies[11,13,29] included a form of control to establish stability of the outcome measure in the absence of intervention. However, each of these studies had methodologic limitations. Repeated baseline measures of the dependent variable were taken in 2 of the studies. One of these studies obtained 3 baseline measurements 24 hours apart, compared with the 10-week time span between pre- and postintervention measurements.[29] The other study[13] that incorporated repeated baseline measures took 2 preintervention measurements, but the time period between these measurements was not reported. Although these trials controlled for confounding variables such as familiarization to the testing procedure and factors related to the reapplication of measurement tools, they did not adequately control for other factors such as natural variability in subject performance over longer periods. The final observational study[11] that included a form of control involved 5 subjects with hemiplegic CP. In this study, the more affected hemiplegic leg was trained while the contralateral leg served as the control limb. The difficulty is that, although no change was detected in the untrained limb, it cannot be assumed that the hemiplegic leg would have shown similar stability without intervention over the same period. Methodologic limitations like these limit the certainty with which conclusions can be made. However, the observational studies, when viewed collectively, provide an indication of the effects of strength training in people with CP.

### Impairment

Eight of the 10 empirical studies we reviewed concluded that strength-training programs increase the muscle strength of people with CP. One of the 8 studies was the RCT by McCubbin and Shasby.[32] These researchers reported increased strength in the triceps (effect size=2.71) after a 6-week isokinetic training program for adolescents with CP. The 2 trials[11,30] that reported no change in muscle strength proved to have had low power. Experiments with low power have an increased risk of the researchers concluding that no difference existed when in fact it did (type II error). Small sample sizes (both n=6) could have affected the power of these 2 studies. For example, if the effect size were maintained in the study by Toner et al,[11] and subject numbers were increased from 6 to 14, there would have been a greater than 80% chance of detecting a significant training effect.

Despite the consistency of findings, wide variability in subject characteristics was evident in the 8 trials that reported positive strength-training effects (table 1). For example, subject age ranged from 6 to 47 years of age, and the severity of disability varied from people who were nonambulatory to people who could walk without assistive devices. The topographic classification (eg, diplegia, quadriplegia, hemiplegia) of CP was similarly varied, although most subjects had spasticity.

Variability was also evident in the training parameters. Differences existed in the muscle group trained, the intensity and duration of the program, the equipment and exercise details, the method used to determine the amount of resistance applied, and the outcome measure used to evaluate muscle strength. The most consistent features of the training programs were that they were performed 3 times a week over 6 to 10 weeks, and there were mechanisms to regularly adjust resistance to ensure that the exercises were of sufficient intensity, in accord with recommendations of the American College of Sports Medicine.[37]

Despite the variability in subject characteristics and program parameters, the literature provides evidence, although it is limited, that strength-training programs may provide positive strength benefits for children and young adults with CP.

There is no empirical evidence that strength training increases spasticity and contractures in people with CP. Some clinicians have argued that people with spastic CP are not weak and that the impaired performance of functional activities commonly observed is primarily a result of spasticity.[38] On the basis of clinical observations, it has been hypothesized that the increased effort associated with strength training would increase spasticity in people with neurologic disorders and this would, in turn, lead to increased muscle and joint contractures and decreased motor function.[39] This view is not supported by the available empirical literature. Studies of the effect of strength training on spasticity show that strengthening has either no effect on, or that training may possibly even reduce, spasticity. Similarly, there is no evidence to support the view that strengthening programs reduce the ROM of people with CP. Rather, the evidence suggests that strength training might lead to increased ROM, particularly in the lower limb.

The only study[29] that investigated the effect of strength training on psychologic impairment evaluated the effects of a group fitness program on the self-confidence and perceived competence of children and adolescents with CP. Strength training was a major component of this community group program. It was found that participation in the training program significantly improved the subjects' feelings about their appearance.

### Activity

Only a handful of studies have measured the effects of a strength-training program on activity in people with CP. A comparison of figures 1 and 2 shows that the effect sizes for activity were generally smaller than the effect sizes for measures of impairment. This is probably because other factors such as sensory function, coordination, and even psychologic factors such as fear contribute to motor performance. Therefore, a strength-training program designed specifically to increase muscle strength might be expected to have a smaller effect on measures of activity than on measures of impairment such as muscle strength.

Significant improvements were found in dimensions[31] D and E[27,31] of the GMFM after subjects completed a strength-training program that targeted muscles of the lower limb. These sections of the GMFM measure activities such as standing alone, moving from sit to stand, walking, running, kicking, jumping, and walking up and down a step. In contrast, no change was detected in the composite GMFM score (ie, the score from sections A–E).[27] The composite score includes items that measure lying and rolling, sitting, crawling, and kneeling, as well as those related to the activities listed above. Again, this finding is not unexpected because Damiano and Abel's training program[27] specifically targeted lower-limb muscles; it seems reasonable to predict that increased lower-limb strength would have less effect on the performance of activities such as sitting or lying and rolling than on activities such as walking, running, and jumping. It is difficult to draw from the literature conclusions about the effects of strength training on mobility in the CP population. With respect to walking speed, 1 study found a positive effect after strengthening,[27] whereas another study detected no change.[31] The tailored nature of the training program may explain these disparate findings. In contrast to MacPhail and Kramer's program,[31] which involved strengthening of the quadriceps and hamstrings regardless of each individual's assessment findings, Damiano and Abel's program[27] targeted training of each participant's weakest lower-limb muscles. This finding suggests that strength-training programs that are tailored to individual needs may result in better functional outcomes than do less individualized programs. Only 1 study[33] investigated the effects of strength training on wheelchair mobility. One of the limitations of that study for the purpose of this review was that equal numbers of children with spina bifida and CP participated in the program, and data from each group were not reported separately. Therefore, the findings of this study[33] with respect to CP should be interpreted with caution. It appears, however, that upper-limb strengthening exercises can improve the endurance of children with CP and spina bifida in wheelchair mobility.

### Participation

Very little research has been conducted examining the effects of strength training on the societal participation of people with CP. Participation was not measured in any of the 10 articles we reviewed. However, it was reported anecdotally that after completing the program, a certain proportion of the participants were confident enough to join a regular community exercise program.[29,30]

### Contextual Factors

Contextual factors are an important consideration in evaluating the effects of strength-training programs. To implement an optimal program, clinicians need information about the effects of different environmental and personal contextual factors. For example, should the program be administered on an individual or a group basis? Is the program best administered in a laboratory, clinical, or community setting? Do the cognitive abilities of the participants affect the success of the program?

Despite the importance of these contextual factors, there was insufficient information in the included articles from which to draw firm conclusions. These factors need to be reported routinely to permit hypothesis generation, which can then be formally evaluated in randomized trials.

### General Discussion

There is a need to complete well-designed trials to evaluate the effects of strength training in the CP population. Currently, it appears that strengthening programs, in general, may be effective in increasing strength in people with CP. However, because of the methodologic limitations of the literature, we are unable to make definitive recommendations. To provide strong evidence to support clinical practice and maximize the mobility, independence, and health of people with CP, researchers must show that strength training is an effective intervention. This could be achieved with well-designed RCTs. Little information is available about the effects of strength training on the activity and participation dimensions of functioning and disability. In the management of CP, it has long been recognized that ". . . the accomplishment of the necessary or useful 'life skills' should be the treatment goal. . . ."[40] However, most studies have only measured changes at the impairment level (ie, muscle strength, spasticity, or joint ROM). Clients, their families, and health service providers are often more interested in measuring the effect of interventions in terms of outcomes that reflect meaningful improvements in a person's ability to function within society. Health care providers must show that their treatments are effective from the clients' perspective. To achieve this, health care providers must incorporate measurements of activity limitations and participation restriction in their assessments and then show that these outcome measurements improve with treatment. This is a challenge that must be addressed.

A limitation of this systematic review was that the criteria for assessing study quality (ie, PEDro Scale, NHS Centre for Reviews) did not include items for assessing the reliability and validity of the tools used in the studies. This would be of greater concern if the studies had reported no effects; however, most of them reported significant results that were consistent with hypothesized changes. This suggests that the measurement tools gave evidence of construct validity and hence adequate reliability.

## CONCLUSION

The results of this review suggest that there is evidence supporting the view that strength-training programs improve muscle strength in children and young adults with CP. In addition, there appear to be no detrimental effects such as increased spasticity. It remains undetermined whether strength training affects the mobility, function, or the ability to participate in normal societal roles. Contextual factors have not been considered adequately. The conclusions drawn from this systematic review are similar to those of Darrah et al,[4] although some of the studies they included in their review we excluded from our review (for methodologic reasons) and we included some more recent studies in our review. More research of higher quality and rigor is required to draw definitive conclusions on the effects of strength training programs for people with CP.

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