

Electromechanically assisted walking in patients with cerebral palsy: A meta-analysis

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Objective: This review aims to analyze the effects of electromechanically assisted walking in patients with cerebral palsy (CP).

Design: A systematic review and meta-analysis.

Methods: We reviewed systematically using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist guidelines. The inclusion criteria for this study were all CP patients. The intervention was electromechanically assisted walking. The outcome measures included gait parameters, function, spasticity. Studies excluded from this review were excluded from the review if they were non-English languages and if the study was not published as a full report, and if they were not randomized controlled trials (RCTs) designs. The RevMan 5.4 program was used to evaluate and explain the results. The risk of bias was evaluated independently by two reviewers. The quantitative meta-analysis, including mean differences (MD) and associated standard deviations (SD) from baseline and follow-up assessments, were recorded.

Results: A total of 634 articles were searched. Two hundred eighty-nine duplicate articles were excluded, and 345 of 634 originals were left for selection. Of these 74 papers, 44 were out of topic, and 19 reported no mean or standard deviation values. And one was a non-experimental study. Finally, ten studies were included. All 10 RCTs of electromechanically assisted walking were analyzed. The meta-analysis showed a significant improvement in gait cycle (95% CI (confidence intervals), 0.09 to 0.19, I²=0%), Gross Motor Function Measure (GMFM) D (95% CI, 3.27 to 13.17, I²=0%) and GMFM E (95% CI, 0.22 to 6.41, I²=0%).

Conclusions: Electromechanically assisted training helps in walking in patients with CP.

Key Words: Cerebral palsy, Walking, Meta-analysis, Electromechanical

Introduction

CP (Cerebral palsy) is caused by posture disorders in daily life and brain malformation or damage during early development [1]. CP is associated with motor impairment and disability throughout life [2]. CP is accompanied by cognitive, motor, and sensory disorders [3]. Movement disorders are often accompanied by cognitive, sensory, and perceptual deficits and communication [4]. Treatment options include physiotherapy; occupational therapy; hippotherapy; orthotics/casting, and postural management [5]. Appropriate evaluation and treatments can

favorably influence prognostic outcomes; thus, several techniques have been developed to evaluate gait function and efficiency [6].

Difficulty with walking is considered the important consequence of CP [7]. Gait speed, stride length, step length, and cadence are important indicators of quality of life and functional mobility [8]. Gait training using the principle of improving neuroplasticity in task-specific training is effective in the rehabilitation process [9]. The gait rehabilitation method in patients with neurological disorders relies on technical devices to induce gait in patients with weight support and emphasizes the

Received: Feb 2, 2021 Revised: Mar 15, 2021 Accepted: Mar 16, 2021

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beneficial role of repetitive exercises [10].

In recent years, robotic systems have been used as part of rehabilitation, developing stance, balance, and movement and promoting cortical reorganization through concentration, control, repetition, and motor learning [11]. The potential benefit of the robotic device is that the robotic walker moves the patient's posture and supports the posture, so there is less risk to users and trainers, and the treatment time can be used more efficiently [12]. There is also robotic equipment, as well as a variety of other mechanical approaches to assisting gait. For example, neuromuscular electrical stimulation (NMES) assisted gait is a development technique that demonstrates its potential as an effective and cost-effective treatment for gait disorders in patients with spastic CP [13].

A meta-analysis of robot gait training in patients with cerebral palsy [14] and a systematic review of robot-assisted gait training for pediatric gait disorders have been previously reported [15]. However, a meta-analysis of the use of robots and other mechanical assistive approaches has not been reported. This review aims to analyze the effects of electromechanically assisted walking in patients with CP.

Methods

Selection of Studies

We reviewed systematically using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist guidelines [30]. The study was approved by the Research Ethics Committee of Sahmyook University (2-7001793-AB-N-012019082HR). The inclusion criteria for this study were all CP patients. The intervention used in the study was electromechanically assisted walking. The outcome measures included gait parameters, function, spasticity. Studies excluded from this review were excluded from the review if they were non-English languages and if the study was not published as a full report, and if they were not randomized controlled trials (RCTs) designs.

The protocol has been pre-registered with PROPERO (CRD42020140076). We searched for studies in EMBASE, PubMed, and Cochrane databases. The search was conducted in April 2019. In EMBASE, ('Cerebral palsy') AND ('Robotics' OR 'Automation' OR 'gait' OR

'walking' OR 'locomotion') AND ('randomized controlled trial') PubMed and Cochrane Library CENTRAL databases were made using the MeSH keywords. See the Appendix for a detailed example of search strategies for EMBASE and Cochrane Library CENTRAL databases.

Quality assessment

The risk of bias was evaluated independently by two reviewers. We independently assessed the risk of bias of individual studies. We assessed by using the Cochrane's Risk of Bias tool (random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other forms of bias) [29]. The RevMan 5.4 program was used to evaluate and explain the results.

Data extraction

We used a search strategy to search and select to include titles and abstracts of studies from additional sources. The deduplication was removed and reviewed concerning the inclusion and exclusion criteria. Two reviewers cross-checked the included studies. The quantitative meta-analysis, including mean differences (MD) and associated standard deviations (SD) from baseline and follow-up assessments, were recorded; any disagreements over study selection and data extraction were discussed by both reviewers.

Data Analysis

Meta-analysis was performed using the Cochrane Library's RevMan 5.4 program. To evaluate the effect estimates for the selected RCTs, the mean and standard deviation values were. A random-effects model was used. Homogeneity was confirmed with the I^2 test. An I^2 value of 0% indicates no heterogeneity, 30–60% indicates moderate heterogeneity, and 75% indicates severe heterogeneity [29]. The meta-analysis were gait parameters, MAS (Modified Ashworth Scale), and GMFM (Gross Motor Function Measure) dimensions D and E.

Results

Study Selection

A total of 634 articles were searched in the PubMed, EMBASE, and Cochrane databases. Two hundred eighty-

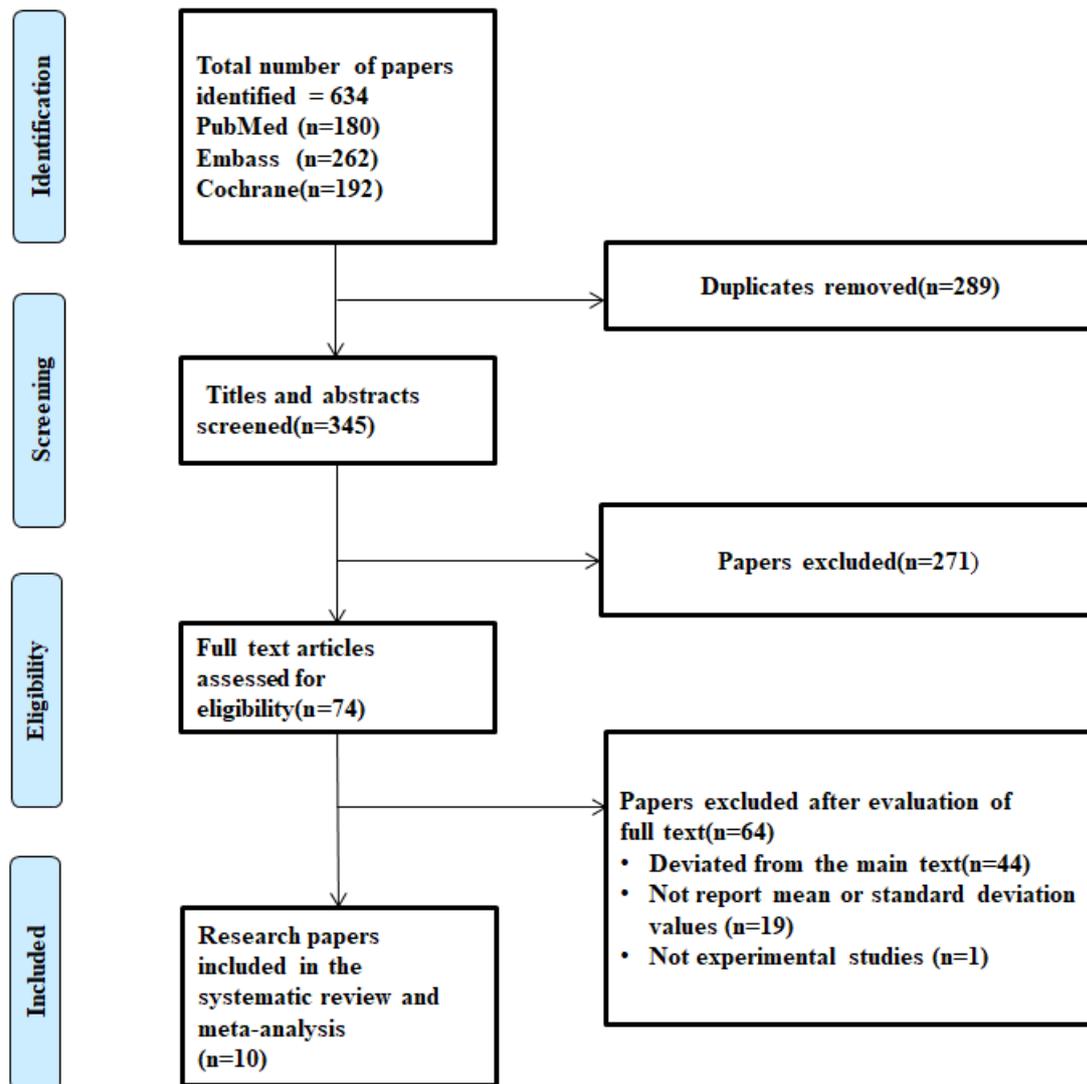


Figure 1. PRISMA flow diagram

nine duplicate articles were excluded, and 345 of 634 originals were left for selection. Of these 74 papers, 44 were out of topic, and 19 reported no mean or standard deviation values. And one was a non-experimental study. Ten studies were finally selected. Ten studies have met all inclusion and exclusion criteria (Figure 1).

Assessment of quality

In five studies, the allocation concealment was described, and in two papers, blinding of the participants and personnel was considered low. Concerning the blinding of outcome assessment data, two articles were shown to have a high bias. Other biases were shown to have a high degree of bias. All ten studies had a low risk

of reporting bias (Figure 2).

Study characteristics

In this study, all 10 RCTs [17, 19-27] of electromechanically assisted walking were analyzed. The interventions used in the electromechanical device: robotic-assisted treadmill, NMES, Partial body weight-supported treadmill training (PBWSTT), balance-based video games, Transcutaneous Electrical Nerve Stimulation (TENS), Functional Electrical Stimulation (FES), whole-body vibration (WBV), extracorporeal shock wave, and speed-focused elliptical (Table 1). [17, 19-27]

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
alabulawahab 2010	+	?	?	?	?	+	+
arya2012	+	+	+	+	?	+	+
damiano2017	+	+	?	+	?	+	+
druzbecki 2013	+	?	?	?	+	+	+
el-shamy2014	+	+	+	?	+	+	+
ho 2006	+	?	?	?	+	+	+
ibrahim2014	+	?	?	?	?	+	+
su 2013	+	?	?	?	?	+	+
tarakci2016	+	+	?	+	?	+	+
wallard2017	+	+	?	?	?	+	+

Figure 2. Methodological evaluation

Meta-analysis

In this study, all 10 RCTs [17, 19-27] of electromechanically assisted walking in patients with cerebral palsy were analyzed.

Gait parameters

Gait parameters were reported in nine studies. [19-27] For seven parameters, a meta-analysis could be performed. The meta-analysis showed a significant improvement in gait cycle (95% CI, 0.09 to 0.19, I²=0%). The meta-analysis showed on walking speed (95% CI, -0.09 to 0.22, I²=58%), step length (95% CI, -2.41 to 6.75, I²=60%), cadence (95% CI, -22.73 to

34.61, I²=82%), Timed Up and Go Test (95% CI, -1.51 to 3.82, I²=0%), step width (95% CI, -1.00 to 1.54, I²=35%), or stride length (95% CI, -0.15 to 0.38, I²=70%) (Figure 3).

GMFM

The GMFM was reported in three studies [17, 23, 25], with a total of eight different gait parameters. For two dimensions of the GMFM, a meta-analysis could be performed. The meta-analysis revealed significant improvements in GMFM D (95% CI, 3.27 to 13.17, I²=0%) and GMFM E (95% CI, 0.22 to 6.41, I²=0%) (Figure 4).

Spasticity

Spasticity was reported in two studies. [24, 26] The meta-analysis showed in the MAS (p=0.07, I²=0%) (Figure 5).

Discussion

This review aims to analyze the effects of electromechanically assisted walking in patients with CP and the first meta-analysis.

One previous meta-analysis analyzed RAGT (robot-assisted gait training) effect on pediatric gait disorders patients. RAGT may help children with gait impairment, especially those with CP [15]. In another meta-analysis, RAGT benefits people with cerebral palsy, specifically by increasing walking ability [14]. However, unlike previous studies, we focused on electromechanically assisted walking, including RAGT, as well as other approaches. A meta-analysis of electromechanically assisted walking following stroke found aid walking [28]. Our results were also shown to aid walking in Electromechanically assisted training.

Walking in cerebral palsy is impaired by the effects of the disease on constant movement and posture [16]. Electromechanically assisted training has great advantages in aiding posture and walking and moves similar to typical walking patterns [17]. To improve walking ability, one can train patients efficiently with repeated electromechanically assisted training. However, electromechanically assisted training needs to walk with equipment, leading to limitations related to cost and locations where the equipment can be used [18].

Table 1. Characteristics of Included Studies

(n=10)

Study	Sample characteristics	Intervention	Control group	Outcomes (Scale)	Results
Su, et al China 2013 [20]	A two period randomized crossover design consisted of 12-week PBWSTT (n=10) and 12-week conventional gait training (n=10)	Type: PBWSTT Format (setting):school Session: 2 time/week 25min for 12 weeks	Convention gait training	1) GMFM 2) gait speed	1) Improved GMFM 2) Improved gait speed
TARAKCI, et al, TURKEY 2016 [21]	RCT of Nintendo will fit video game on balance in children with mild CP (n=15) and NDT and conventional balance training (n=15)	Type: Balance Based Video Games Format (setting): unclear Session: 1 time/week 50min for 12 weeks	conventional balance training	1) TUG 2) 10MWT 3) 10SCT 4) locomotion	1) Improved gait
ALAbdulawaha b, & Maha Al-Gabbani Saudi Arabia 2010 [22]	RCT of conventional TENS on spasticity in hip adductors and gait parameters of children with spastic diplegic CP (n=27)	Type: TENS Format (setting):rehabilitation centers and hospitals Session:15min/session, 3times a day for one weeks	conventional gait training	1) Step width 2) Step length 3) Gait speed 4) MAS	1) Improved gait 2) decreased spasticity
Arya et al., USA 2012 [23]	RCT of NMES therapy of quadriceps femoris and tibialis anterior muscles on improving gait and functional outcomes in children with spastic CP (n=10)	Type: NMES Format (setting): rehabilitation institute Session:20-30min/session , 4-5 for 4 weeks	Conventional muscle strengthening exercise	1) Gait speed 2) Cadence 3) Step length 4) GMFM	1) Improved gait 2) Improved GMFM
Ho et al., USA 2006 [24]	RCT of Changes Dynamic Resources in Children With Spastic CP (n=15)	Type: FES Format (setting): community Session: 15 trials	conventional gait training	1) Gait speed 2) Stride length	1) Improved gait
Ibrahim et al., Egypt 2014 [25]	RCT of WBV group received the same program in addition to WBV training (n=30) and physical therapy treatment program for spastic diplegic CP (n=30)	Type: WBV Format (setting): University Session: 60min/session, 3 times/week for 12 weeks	conventional gait training	1) 6MWT 2) TUG 3) MAS	1) Improved gait 2) decreased spasticity
El-Shamy et al., Egypt 2014 [26]	RCT of the effects of shock wave therapy on gait pattern in children with hemiplegic CP (n=15)	Type: Extracorporeal shock wave therapy Format (setting): University Session: 3 month	conventional gait training	1) Gait speed 2) Cadence 3) Stride length 4) cycle time	1) Improved gait
Druzbecki et al., Poland 2013 [19]	RCT of study group used active orthosis in addition to following a programme of individual exercises (n=26) and control group participated only in individual exercises (n=9)	Type: robotic-assisted treadmill therapy Format (setting): unclear Session: 45 min 20session	conventional balance and gait training	1) Gait speed 2) Step width 3) cycle time	1) Improved gait

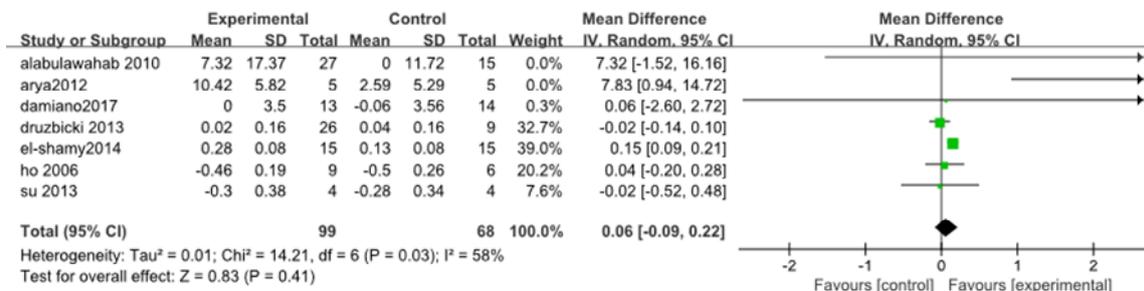
Table 1. Characteristics of Included Studies (Continue)

(n=10)

Study	Sample characteristics	Intervention	Control group	Outcomes (Scale)	Results
Damiano et al.,USA 2017 [27]	RCT of Speed-Focused Elliptical (n=13) or Motor-Assisted Cycle Training (n=14) in Children With CP	Type: Speed-Focused Elliptical Format (setting): home Session: 20 minutes, 5 days a week for 12 weeks.	motor-Assisted cycle trianing	1) Gait speed 2) cycle time	1) Improved gait
Wallard et al., France 2017 [17]	RCT of RAGT on the dynamic equilibrium control during walking in children with CP (n=14) and receiving only daily physiotherapy (n=16)	Type: robotic-assisted treadmill therapy Format (setting): hospital (center) Session: 1-20 session/week during 4 weeks	conventional balance training	1) GMFM 2) Kinematic parameter	1) Improved GMFM

CP: cerebral palsy, GMF: gross motor function measure, RAGT: robot-assisted gait training, PBWSTT: partial body weight-supported treadmill training, NDT: neuro-developmental treatment, MAS: modified Ashworth Scale, TUG: timed up and go test, 10MWT: 10 meter walking test, 6MWT: 6 meter walking test, 10SCT: 10 stair climbing test, TENS: transcutaneous electrical nerve stimulation, FES= functional electrical stimulation , WBV: whole-body vibration

Walking speed



Step length

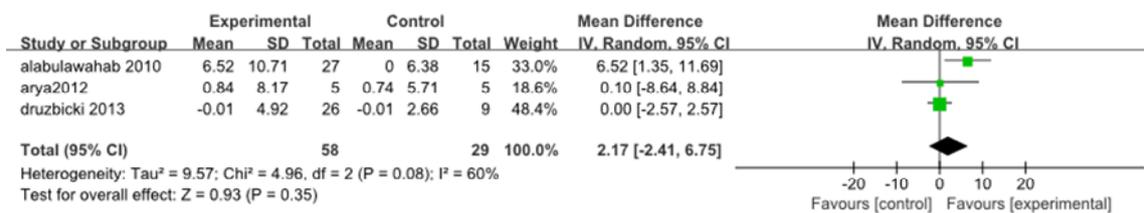
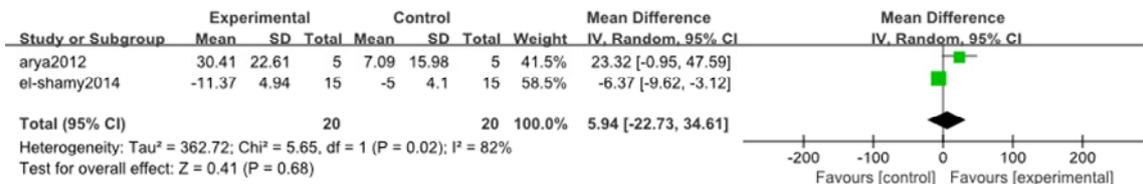
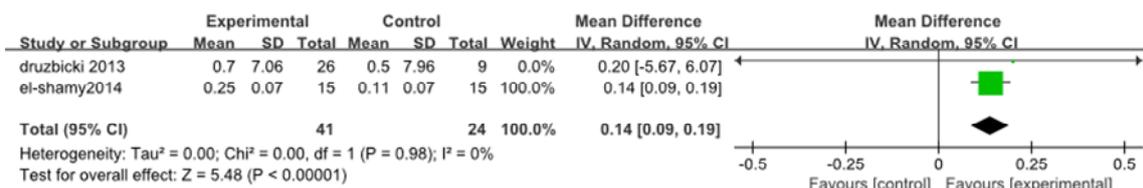


Figure 3-1. Forest plots of the effects on gait parameters

Cadence



Gait cycle



TUG

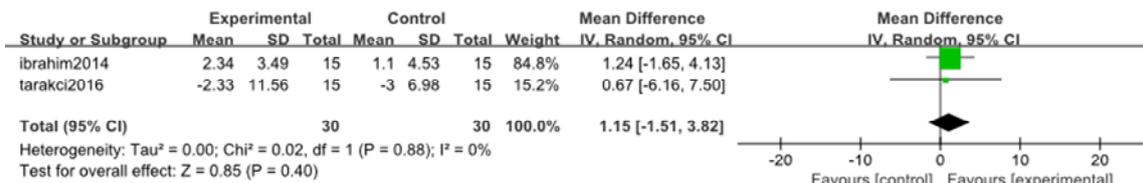
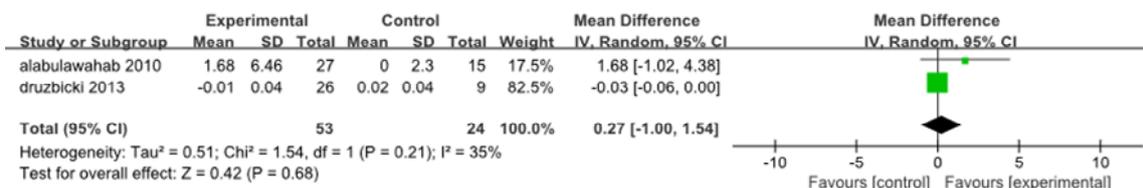


Figure 3-1. Forest plots of the effects on gait parameters (Continue)

Step width



Stride length

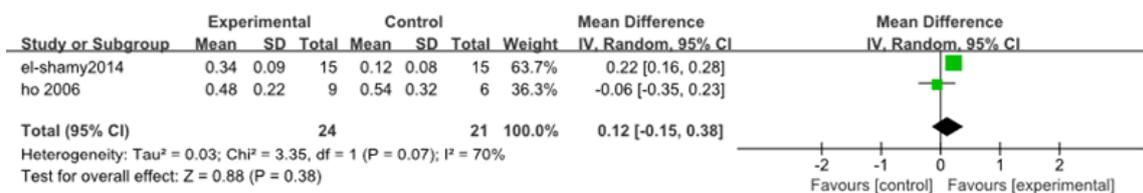
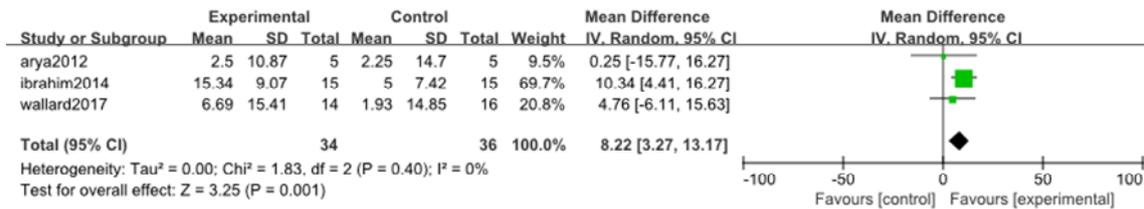


Figure 3-2. Forest plots of the effects on gait parameters

GMFM D



GMFM E

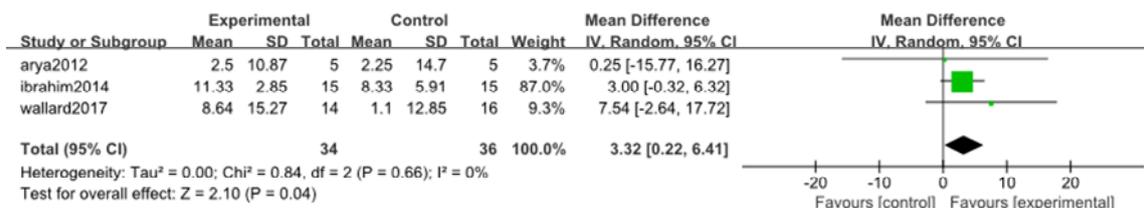


Figure 4. Forest plots of the effects on GMFM

MAS

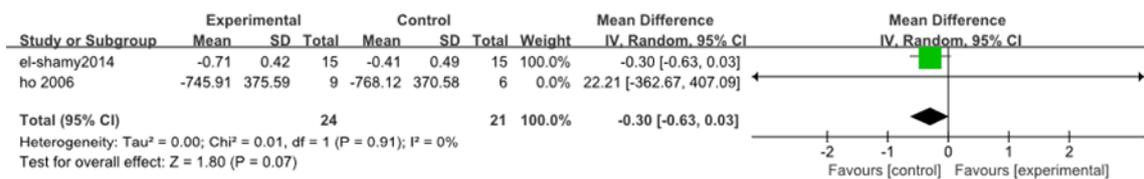


Figure 5. Forest plots of the effects on spasticity

When analyzing the electromechanical gait of the intervention type of the studies, two studies [17, 19] used a robot-assisted treadmill, and eight studies [20-27] examined other machines. In the two selected robot-assisted treadmill studies, Lokomat showed improved stability-related metrics [19]. In other studies, the usefulness of the RAGT was mainly related to balance control during gait [17].

Eight studies [20-27] examined other machines to assist gait. In one study, PBWSTT examined the effectiveness of improving gross motor skills. Significant improvements in walking speed have been reported after treadmill training, along with a significantly higher score of total motor function related to walking [20]. Wii-Fit balance-based video games were effective in improving performance-related balance parameters [21]. The use of TENS to hip adductors in CP can improve gait patterns and reduce spasticity [22]. NMES therapy and

conventional physiotherapy improve walking ability in cerebral palsy [23]. FES was effective in increasing impulse during walking [24]. WBV improves muscle strength, gait speed, and gross motor performance [25]. Shock wave therapy was effective in improving spasticity and gait pattern [26]. Speed-focused elliptical-Task-specific effects were equally positive among groups but showed no gait or transfer of functions [27].

We found the effects of electromechanically assisted walking on gait parameters, function, and spasticity in patients with CP. This study improved significantly in the gait cycle and GMFM (D and E). Electromechanically assisted training helps in walking in patients with CP.

The limitation of this review was that the walking aids were analyzed, including the various electromechanicals of cerebral palsy patients, but included studies were small, so the evidence of meta-analysis was weak, and this review was only published in English not

including various languages. In future studies, included studies should be performed using sufficient size, and a survey of the balance of Electromechanically assisted training is also suggested.

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