

# The Effect of Transcranial Direct Current Stimulation on Balance and Mobility in Children with Cerebral Palsy: A Systematic Review



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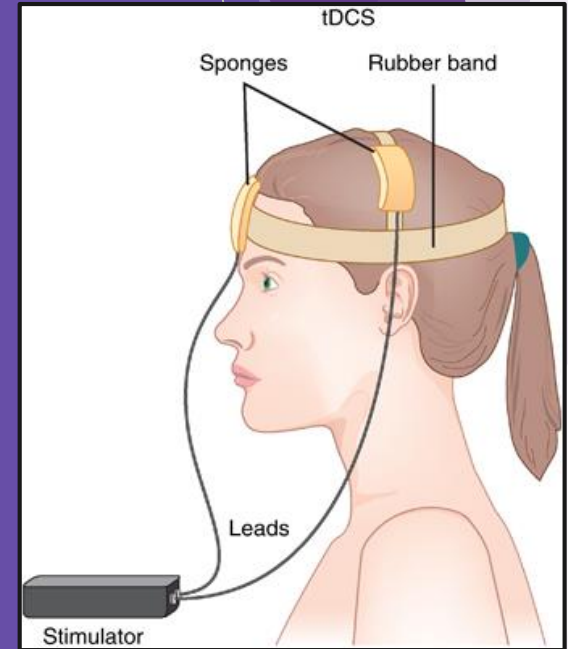
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# Overview

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# What is Transcranial Direct Current Stimulation (tDCS)?

- A form of *non-invasive brain stimulation* (NIBS) - emerging approach for enhancing neuroplasticity and rehabilitation outcomes<sup>1</sup>
- How does it work?
  - Applies a weak and constant direct current to brain
  - Enhancement vs. Suppression of cortical excitability
  - Lasts up to several hours after stimulation
- Hypothetically → modulates neuronal inhibitory and excitatory networks of affected and non-affected hemispheres



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# What is tDCS? (cont'd)

Three different stimulation types<sup>1</sup>:

1. Anodal stimulation (+) → placed over lesioned brain area
  - Stimulates affected side
2. Cathodal stimulation (-) → placed over non-lesioned brain area
  - Inhibits non-affected side
3. Dual tDCS → simultaneous application of anodal and cathodal stimulation

# Why does tDCS matter?

- Ideal adjuvant therapy for stroke rehabilitation<sup>1</sup>:
  - Relatively inexpensive
  - Easy to administer
  - Enhances motor learning
  - Portable
  - Non-invasive
  - Minimal side effects
- Impairments/limitations of cerebral palsy that tDCS targets<sup>2,3</sup>:
  - Compromised gait (velocity)
  - Spasticity
  - Motor learning

# Purpose

- To review the effect of transcranial direct current stimulation (tDCS) on balance/mobility in children with cerebral palsy (CP)

# Search Terms

- Pediatric **AND** (cerebral palsy **OR** perinatal stroke **OR** stroke) **AND** (direct current stimulation **OR** current stimulation **OR** transcranial **OR** stimulation **OR** microcurrent)
- Search Limits:
  - Human Subjects
  - English Language
  - Peer-reviewed

# Databases

- CINAHL
- Cochrane
- PubMed
- ProQuest Central
- ScienceDirect

Two reviewers independently assessed each study



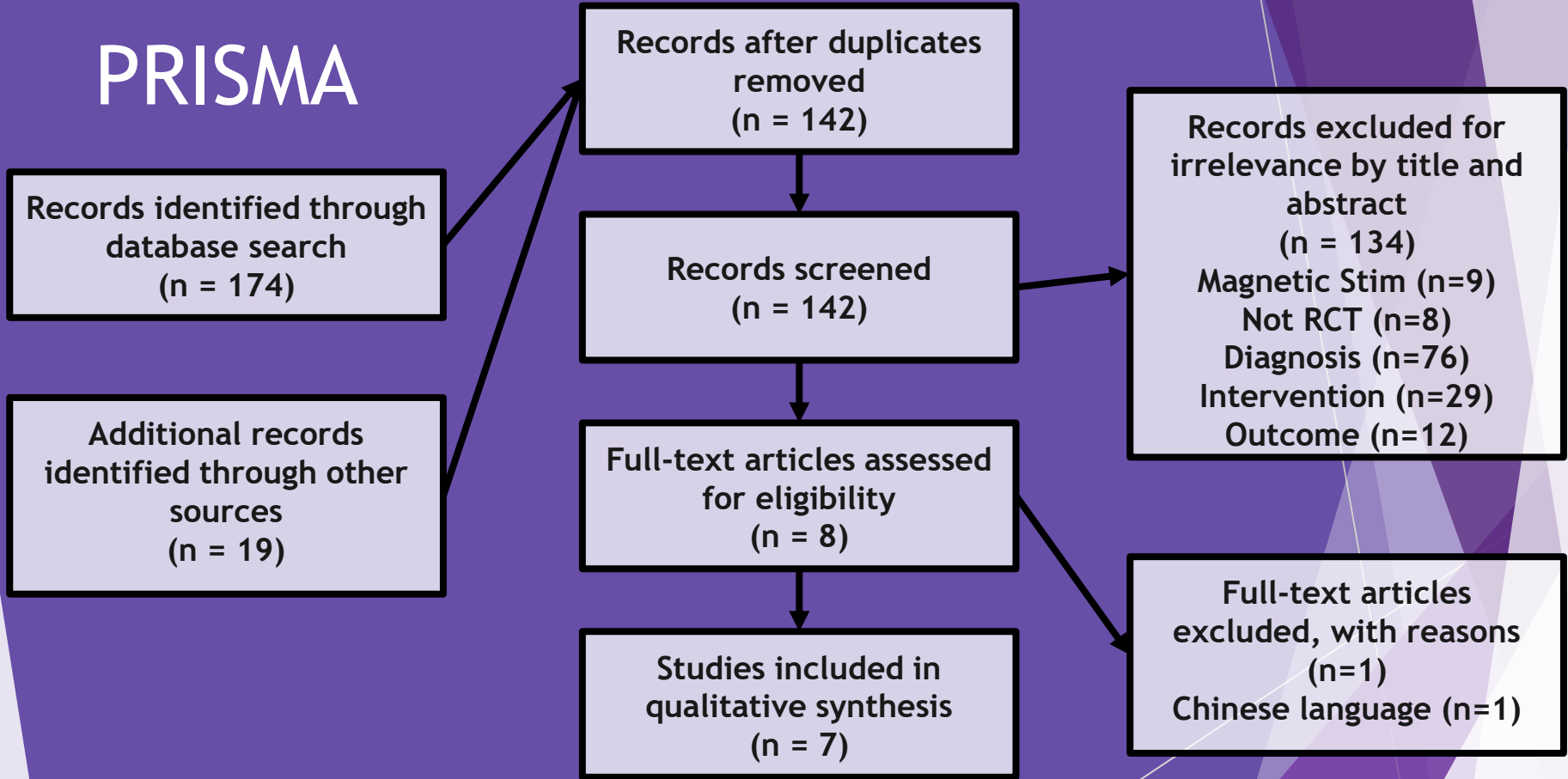
## Inclusion Criteria

- Pediatric (Birth - 18 y/o)
- Randomized Controlled Trials (RCTs)
- Intervention included tDCS

## Exclusion Criteria

- Children not diagnosed with CP
- No outcome measures for balance/mobility
- Pharmacological co-intervention

# PRISMA



# PEDro

<b>Article by Author</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>Total Score</b>
Grecco et al. <sup>2</sup>	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	<b>8</b>
Duarte et al. <sup>3</sup>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	<b>10</b>
Grecco et al. <sup>4</sup>	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	<b>9</b>
Grecco et al. <sup>5</sup>	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	<b>9</b>
Lazzari et al. <sup>6</sup>	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	<b>9</b>
Ferreira et al. <sup>7</sup>	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	<b>9</b>
Lazzari et al. <sup>8</sup>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	<b>10</b>

# Results

- PEDro scores for 7 articles ranged from 8 to 10/10 (mean=9.14)<sup>2-8</sup>
- Samples ranged from 6 to 24 subjects (126 total)
- Children aged 4-12
- CP Gross Motor Function Classification System (GMFCS)
  - Levels I-III
- Treatment parameters
  - 1 mA of anodal tDCS applied over:
    - Primary motor cortex in 6 studies<sup>2-3,5-8</sup>
    - Cerebellum in 1 study<sup>4</sup>

## Results (cont'd)

- Interventions were applied by a PT
  - Five studies applied tDCS for five 20-minute sessions for 2 weeks<sup>2-6</sup>
  - Two studies applied a single session for 20 minutes<sup>7,8</sup>
  - Four combined tDCS with virtual reality (VR)<sup>2,6-8</sup>
  - Three examined tDCS with treadmill training (TT)<sup>3-5</sup>
- Outcomes included:
  - Temporal distance (gait analysis, 6MWT)<sup>2,5</sup>
  - Kinematic analysis (Gait Profile Score)<sup>2,5</sup>
  - Functional performance (GMFM-88, PEDI, TUG)<sup>2-7</sup>
  - Balance (sway, PBS)<sup>3,4,6,8</sup>

## Results (cont'd)

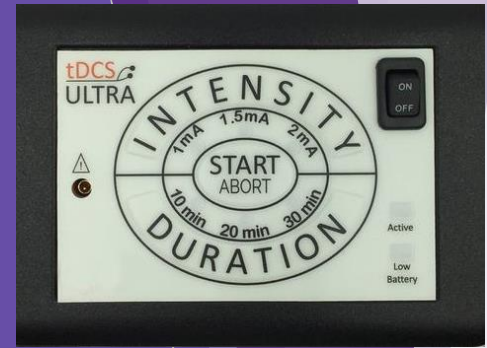
- Statistically significant improvements ( $p < 0.05$ ) in balance and/or mobility with co-interventions as compared to usual care
  - 6/7 studies
    - 3 VR<sup>2,6-7</sup>
    - 3 TT<sup>3-5</sup>
- Sustained improvements at 1-month follow up
  - 5/7 studies<sup>2-6</sup>
- Significantly greater improvements ( $p < 0.05$ ) with anodal tDCS combined with VR or TT as compared to a control<sup>2-7</sup>

# Conclusion

- Strong evidence to support the use of tDCS combined with VR or TT to improve balance/mobility in children with CP
- Immediate improvements in gait and sway velocity exhibited in the single session studies
- Sustained improvements in balance/mobility at 1-month follow-up in five studies conducted over a 2-week period

# Clinical Relevance

- Currently not FDA approved for clinical use<sup>9</sup>
- Clinical use:
  - Out of pocket treatment-pricing intervention
  - Used in conjunction with insurance billable functional interventions
  - Prior to initiation of tDCS patient is cleared by MD
  - Consent form is explained and signed
  - Following each treatment a brief questionnaire is completed to document any side-effects<sup>2-8</sup>



<https://caputron.com/products/tDCS-ultra>

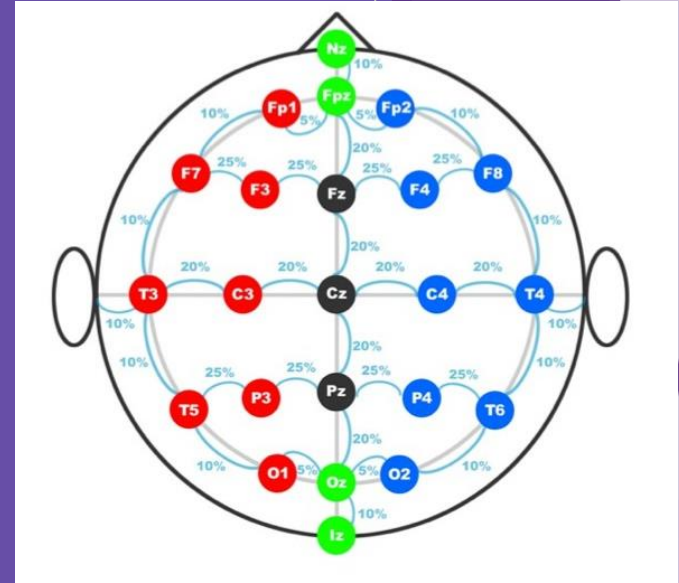


<https://caputron.com/products/tDCS-ultra>



## Clinical Relevance (cont'd)

- Treatment set-up:
  - Acquire tDCS ULTRA device
    - \$299.99
  - Acquire 0.9% NaCl irrigation solution
    - 500 mL - \$9.99
  - Determine electrode placement based on 10/20 System Positioning



# Limitations

- Small sample size
- Wide range of subject impairment levels (GMFCS I-III)
- Various outcome measures
- Lack of long-term follow up
- Repeated authors

# Future Research

- Should focus on the effect of tDCS at different:
  - Intensities
  - Duration
  - Frequency
- Determine the ideal parameters of treatment to increase function

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Comments?  
Questions?

# Appendix



# Gross Motor Function Classification System (GMFCS)<sup>10</sup>

Level I	Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited.
Level II	Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas or confined spaces. Children may walk with physical assistance, a hand-held mobility device or used wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping.
Level III	Children walk using a hand-held mobility device in most indoor settings. They may climb stairs holding onto a railing with supervision or assistance. Children use wheeled mobility when traveling long distances and may self-propel for shorter distances.
Level IV	Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community children are transported in a manual wheelchair or use powered mobility
Level V	Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements.

# Outcome Measures - Description

<u>Test and Measure</u>		<u>Purpose</u>	<u>Age Category and Details of Test and Measure</u>
<b>Gait Analysis<sup>2</sup></b>	Cadence	Number of steps in a time unit (steps/minute)	N/A
	Gait Velocity	Speed of ambulation in meters/second	N/A
<b>Gait Profile Score</b>		Summarizes the overall deviation in kinematic gait data relative to normative data	Based on 15 kinematic variables including pelvic anterior/posterior, pelvic up/down obliquity, left-side rotation, hip flexion, abduction, internal rotation, knee flexion, dorsiflexion, and foot progression for the left and right sides

# Outcome Measures - Description (cont'd)

<u>Test and Measure</u>		<u>Purpose</u>
<b>Gross Motor Function Measure (GMFM-88)</b>	Shows quantitative assessment of gross motor function in individuals with cerebral palsy <sup>2</sup>	Includes 88 items among 5 subscales: <ul style="list-style-type: none"> <li>• Lying down and rolling</li> <li>• Sitting</li> <li>• Crawling and kneeling</li> <li>• Standing</li> <li>• Walking, running, jumping</li> </ul>
<b>PEDI</b>	Quantitatively measures functional performance	Children aged 6 months- 7.5 years in three categories: self-care, mobility and social function <sup>2</sup>
<b>Stabilometric Analysis</b>	Use of force plate to measure oscillations in center of pressure in anteroposterior and mediolateral directions <sup>5</sup>	

# Outcome Measures - Description (cont'd)

<u>Test and Measure</u>	<u>Purpose</u>	<u>Age Category and Details of Test and Measure</u>
PBS	Examines functional balance in pediatric population <sup>5</sup>	14 tasks similar to activities of daily living that are scored on a 5-point ordinal scale  Determines level of assistance needed to perform the tasks
TUG	A test of basic mobility requiring static and dynamic balance <sup>5</sup>  Involves standing up from armless chair, walking 3 meters, turning around, walking back to the chair and sitting down again	
6MWT	Quantifies functional mobility based on distance in meters traveling in 6 minutes <sup>4</sup>	