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Systematic Review
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Systematic Review of Electromyography for Assessing Physiotherapy Outcomes in Children with Cerebral Palsy

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ABSTRACT

Background: Cerebral palsy is a disorder that affects the movement and posture of the brain of a developing fetus or baby. The prevalence is around 1-4 per 1000 live births globally, with 9 birth cases in Indonesia. CP children experience various sensory and motor disorders. Various interventions require a tool that can reliably detect the success of therapy. Electromyography (EMG) is an objective method for understanding muscle activity, helps in determining the muscles involved in movement, and provides related information about muscle activity in response to therapy. This study aimed to determine EMG in evaluating the results of therapy.
Subjects and Method: A literature search was carried out using 2 databases, namely PubMed and Google Scholar regarding the use of EMG to assess or analyze physiotherapy interventions given to children with CP from the period 2018 - 2023. Using PRISMA as a writing rule.
Results: 8 studies described the use of EMG in physiotherapy, 3 articles looked at muscle activity, 3 articles assessed muscle activation, 1 article assessed spastic responses, and 1 article looked at motor neuron excitatory pools.
Conclusion: EMG helps physiotherapy in seeing muscle activity, muscle activation, seeing the spastic response of a muscle, and measuring the collection of excitatory motor neurons.

Keywords: Cerebral palsy, electromyography, spasticity, hemiplegia, diplegia

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BACKGROUND

Cerebral Palsy (CP) is a group of permanent disorders affecting the development of movement and posture resulting in physical limitations with non-progressive disorders occurring in the brain of the developing fetus or baby (Novak et al., 2017). Clinical diagnosis is based on a combination of clinical and neurological signs which usually occurs between the ages of 12 months and 24 months (Novak et al., 2017). According to the CDC, the prevalence of cases in the world is 1 to 4 per 1000 live births. Basic Health Research (Riskesdas) results are 0.09% of the number of children aged 24 – 59 months (Sopandi et al., 2021). This shows that there is a large number of CP cases in

Indonesia, namely 9 cases in every 1000 births.

Children with cerebral palsy (CP) experience sensory and motor disorders, which are categorized into four types: spasticity, dyskinesia (including dystonia and athetosis), ataxia, and hypotonia. These motor impairments can change within the first two years. Dyskinesia, ataxia, and hypotonia typically affect all four limbs, while spasticity is classified into hemiplegia, diplegia, and quadriplegia. Common limitations include chronic pain, epilepsy, intellectual disability, musculoskeletal issues, behavioral disorders, sleep disturbances, reduced vision, and hearing loss (Novak et al., 2017).

Physiotherapy has an important role in improving growth and development and musculoskeletal problems. Brain damage that occurs results in motor disorders in the form of muscle weakness, loss of motor control, and balance disorders (Analauw, no date). The task of a physiotherapist is to reduce spasticity, increase muscle strength, and improve balance. All of these things require quite a long time to see the changes that occur after therapy is given and the results cannot be seen immediately. Therefore, physiotherapy needs a tool to clearly understand the significance of the intervention that has changed the success of therapy.

Electromyography (EMG) is an objective and reliable method for describing the function and level of effectiveness of muscles by identifying the electrical potential in muscle fibers (Szyszka-Sommerfeld, Lipski and Woźniak, 2020). EMG helps in determining muscle participation in a particular movement or observing muscle activetion in a segment in response to the mobilezation of another segment. EMG signals provide the patient and therapist with information regarding the moment of activation of the muscle being treated (Massó et al., 2010). The benefits of EMG itself have been proven effective for CP children with treatment through bobath exercise, gait training, strength training, and mirror therapy (Schmidt, Gerzson, and de Almeida, 2020). Thus, EMG makes it possible to analyze muscles in performing certain tasks and to evaluate the effectiveness of the therapy used.

SUBJECTS AND METHOD

1. Study Design

This study used a systematic review with the PRISMA-P (Preferred Reposting Items for Systematic Review and Meta-Analysis Protocol) method (Hutton et al., 2015). Search for articles using 2 databases, namely PubMed and Google Scholar by entering keywords such as "cerebral palsy" AND "electromyography" AND "Physiotherapy".

2. Inclusion Criteria

The inclusion criteria for this research are journals spanning 2018 – 2023, CP children aged 1 to 18 years, in the EMG trial used as an evaluation of physiotherapy treatment.

3. Exclusion Criteria

Exclusion criteria were literature studies, surgical intervention, and administration of injection therapy.

4. Study Extraction

Each manuscript is evaluated by looking at the journal in which it was published as well as its main characteristics. Table 1 provides a summary of this information

5. Data Synthesis

Elements of research objectives, research design, sample characteristics and results are used to extract the results from each character into a matrix (Table 1).

RESULTS

An initial search of two databases yielded 4,133 potential studies. After removing

duplicates with Mendeley, 2,392 articles remained. Filtering by abstract and criteria reduced the list to 8 studies. The research focused on respondents with CP aged 1-18 years, who received various interventions, with EMG used to measure therapy outcomes. Details are in Table 1.

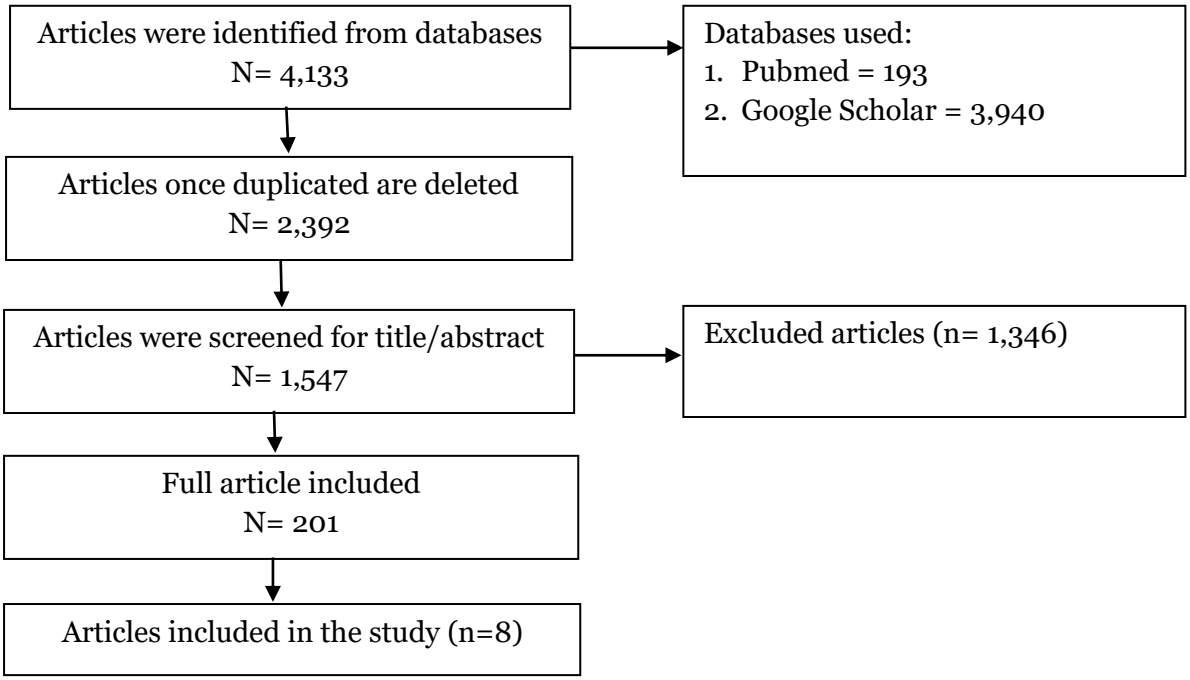

Figure 1. Review Flow Chart of The Use of Electromyography to Measure Physiotherapy Outcomes in Children with Cerebral Palsy

Table 1. Article search results of of the use of electromyography to measure physiotherapy outcomes in children with cerebral palsy

Author (Year)	Method	Sample	Inter-ventions	Results	Conclusion
González et al., (2020)	Randomized Clinical Trial	27 children with spastic CP	Slackline training	In static posturo-graphy (p=0.006) and jumping exercises (p=0.015)	Slackline Training improves static posture and motor skills
Hegazy et al., (2020)	Randomized Controlled Trial	30 spastic CP children	Combining ionthophoresis with exercise	There was an increase in walking speed (p=0.03), cadence (p= 0.001), cycle time (p= 0.0001), and H/M ratio (p=0.02)	Lidocaine ionthophoresis combined with exercise effectively improves gait and reduces spasticity
Kruse et al., (2022)	Randomized Clinical Trial	18 children with spastic CP	Comparing PNF with Static Stretching	Both ankle ROM and maximum dorsi flexion increased ($p<0.05$, $p<0.05$)	Static Stretching acutely increases the lengthening of the muscle-tendon unit, stretching the PNF, showing different effects on spastic muscles

Author (Year)	Method	Sample	Inter-ventions	Results	Conclusion
Wang et al, (2023)	Randomized Controlled Trial	100 CP children	Rehabilitation intervention takes the form of an exercise and education program for parents	Active and passive IMMG values in the gastrocnemius and tibialis anterior muscles in the study group were higher than in the control group (p=<0.05)	Intervention with the family hospital rehabilitation model is beneficial in improving self-care abilities, cognitive function, daily activities of children with CP, improving walking function, and strengthening the child's quality of life.
Daly et al., (2019)	Cross-sectional study	10 CP children	Gluteal strengthening exercise	The activation difference was found to be statically significant using the Friedman test (GMax p = 0.0001, GMed p= 0.0023)	Set-up exercises are most effective in activating target muscles in the CP population
Akbaş & Günel, (2019)	Randomized Controlled Trial	36 spastic CP children	Trunk Training	There was no difference in muscle tone in the two groups (p>0.05). The maximum sEMG score for the erector spine muscles (p=0.025 for the right and p=0.006 for the left) increased in the trunk training group.	Individually structured trunk training is a promising method for increasing trunk extensor activation
Kalkman et al., (2019)	Randomized Controlled Trial	22 Spastic CP children	Comparison of Resistance Training with stretching	Resting fascicle and tendon stiffness increased more in the intervention group compared with the control group. The maximum dorsiflexion angle increased equally in both groups.	This study provides proof of principle that a combined resistance and stretching intervention can increase tendon stiffness and muscle length in children with CP.
Bekius et al., (2021)	Experimental	40 children (20 CP, 20 normal)	Treadmill	Children with CP get less synergy than normal children	Children with CP have less synergy compared with normal children with similar walking abilities who are already in the early phase of motor development.

From the 8 articles that were reviewed, there was a total sample of 257 children, consisting of 237 CP children and 20 normal children. The age level of children ranges from 1 – 18 years old. Judging from the methods used when conducting the research, there were 2 randomized clinical trial articles, 4 randomized controlled trial articles, 1 cross-sectional study article, 1 I. Based on the severity of CP as assessed by the Gross motor function classification system (GMFCS), there were 2 studies that analyzed children -children with GMFCS I and II, 3 studies with GMFCS I - III, 2 studies with GMFCS I – V, 1 study that did not mention the GMFCS classification used. Based on the type of CP, 7 studies used the spastic type with 2 studies including ataxia, mixed and involuntary exercise types. Regarding CP topography, 4 studies evaluated hemiplegic and diplegic children, 1 study evaluated hemiplegia, 1 study evaluated diplegia, 2 studies did not explain this.

DISCUSSION

EMG has become a tool commonly used by physiotherapists because of its ability to display muscle responses to nerve stimulation without being invasive. Observe the intensity, duration and type of muscle contractions, as well as changes in motor unit composition of the muscle training program, nerve recruitment strategies and assessment of muscle weakness. Therefore, EMG has several applications in physiotherapy, both to assess the effectiveness of a given therapy and to show differences in muscle activation between muscle groups.

Three articles used EMG to see muscle activity, in research (González et al., 2020) provided intervention in the form of slackline exercise with 3 sessions/week (30 minutes/ session) for 6 weeks. The EMG results found no changes in the three main postural muscles of the foot (soleus, tibialis anterior, and peroneus longus). These findings are in accordance with previous studies that analyzed the effects of slackline training on EMG in trunk and lower limb muscles in different populations (Keller et al., 2012; Santos et al., n.d.). Overall, slackline exercise does not provide a stimulus high enough to cause changes in EMG.

Wang (2023) found that routine hospital interventions and monthly health education for parents improved knowledge about children with cerebral palsy (CP). The study observed that EMG values for the gastrocnemius and anterior tibialis muscles during passive activities were higher in the study group compared to the control group, while EMG values for active activities were lower in the study group. Bekius et al. (2021) compared walking patterns between children with CP using treadmill support and normally walking children. The study showed that children with CP recruited fewer muscle synergies—three or four—while normal children recruited three to five synergies, indicating that children with CP have fewer muscle synergies even when using support and during early independent walking.

Three articles used EMG as muscle activation. Research by (Kruse et al., 2022) with interventions comparing PNF with static stretching using EMG signals from the tibialis anterior and gastrocnemius lateralis to evaluate muscle activation in reaction to passive foot movements. Research by (Daly et al., 2019) used gluteal strengthening exercise intervention consisting of clam, lunge, squat, step-up, single leg bridge, prone hip knee extension. EMG was placed on the gluteus medius and maximus, showing different results in the activation of the six exercises used. EMG data on step-up exercises shows the most effective results in activating the gluteus medius and gluteus maximus. Akbaş & Günel, (2019) used trunk

training given for 45 – 75 minutes twice a week for 8 weeks. EMG in this study provides information regarding muscle activation patterns. The muscles observed were the lumbar multifidus, erector spine, gluteus maximus, rectus abdominis, internal oblique-transversus abdominis and external oblique. The observations made showed a decrease in the minimum EMG value in the rectus abdominis and internal oblique-transversus abdominis muscles. EMG activity decreases at rest because the child is able to maintain a stable sitting position and achieve good postural control.

Administration of lidocaine iontho-phoresis combined with exercise helped improve gait and reduce spasticity in research by Hegazy et al., (2020), training in the form of traditional sports which was carried out for 3 months 3 times a week, 1 hour each session. EMG is used to assess muscle tone by using the Hoffman/ Myogenic reflex response ratio in the soleus muscle and recording signals from muscles that have been stimulated by the tibial nerve in the popliteal fossa. The EMG results showed a significant difference between the experimental and control groups regarding the H/M ratio (p=0.03). These differences were in walking speed (p=0.03), stride length (p=0.04), cadence (p=0.0001), and cycle time (p=0.0001). EMG assesses soleus muscle tone and measures motor neuron excitability that reflects the level of spasticity.

Kalkman et al. (2019) used Resistance Training with stretching and employed EMG to observe spastic responses in the lateral gastrocnemius muscle of children with CP. EMG is commonly used by physiotherapists to assess muscle activity, activation, spastic responses, and motor neuron excitability. However, the study has limitations, including variations in interventions, differences in frequency, duration, and timing of interventions, and a lack of definitive statistical results.

AUTHORS CONTRIBUTION

Author 1 searched and identified and compiled the manuscript. Author 2 as a supervisor in writing articles and correcting manuscripts.

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CONFLICT OF INTEREST

There is no conflict of interest.

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