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SYSTEMATIC REVIEW

Effect of physiotherapeutic intervention on the gait after the application of botulinum toxin in children with cerebral palsy: systematic review

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ABSTRACT

INTRODUCTION: Cerebral palsy is a group of movement and posture development disorders. 90% of this population has gait impairment, often due to the presence of spasticity. A number of studies emphasize the importance of combined physical therapy with botulinum toxin A treatment. However, no consensus can be reached concerning the content of the physiotherapy program after treatment with botulinum toxin A. The purpose of the present study was to investigate, through a systematic review of the literature, the effects of physiotherapeutic intervention on gait after botulinum toxin application in children with cerebral palsy.

EVIDENCE ACQUISITION: PubMed, Scielo, Cochrane Library, OTseeker, and PEDro databases were searched for randomized trial published between January 2000 and January 2017.

EVIDENCE SYNTHESIS: Sixty-eight articles were identified, four of which met the eligibility criteria and were selected for the present systematic review. A table was created showing the main characteristics of the studies (groups, inclusion criteria, dosage, injection site, physiotherapeutic intervention, evaluation and outcomes).

CONCLUSIONS: This study offers a view on the increase in the therapeutic effectiveness of botulinum toxin A on the lower limbs when used in conjunction with a physiotherapeutic intervention, with improvements in mobility, gait pattern, range of motion and spasticity, which are maintained after the end of the physical therapy protocol. The use of botulinum toxin A on the lower limbs when used in conjunction with a physiotherapeutic intervention, can improve muscle tone, allowing a combined treatment and intended to provide improvement of motor ability and functional skills, and potentially, delay the need for surgery.

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KEY WORDS: Botulinum toxin type A - Rehabilitation - Cerebral palsy - Child - Gait - Physical therapy modalities.

Introduction

Cerebral paralysis (CP) is a group of movement and posture development disorders attributed to non-progressive disturbances having occurred during the development of the fetal or infant brain, resulting in chronic physical deficiencies and often sensory deficiencies that cause limitations regarding activities of daily living.[1] Motor impairment is the fundamental characteristic of CP and is characterized based on the type of motor disorder (spasticity, ataxia, dystonia or athetosis) as well as the distribution of the affected limbs (hemiparesis, diparesis or tetraparesis).[2]

The prevalence of CP ranges between 1.5 and 2.5 per 1000 live births, with few or no differences among Western nations, despite the lack of data on Latin American countries.[3]

Spasticity is a common disabling characteristic stem-

ming from neurological impairment and can lead to pain and the loss of mobility. The result is an increase in muscle velocity dependent on resistance to passive stretching.[4] Spasticity is more difficulty to characterize than recognize and even more difficult to quantify due to the subjective nature of the examination. Nonetheless, the Ashworth scale is the most widely employed for the quantification of spasticity.[5] This scale is used to measure muscle tone, which is classified numerically on a scale from 0 (no increase in tone) to 5 (joint stiffness) based on the degree of resistance during the passive movement of a joint.[6]

Interventions targeting spasticity may involve intramuscular nerve block agents (alcohol, phenol or botulinum toxin A), intrathecal injection (baclofen), surgical procedures (tenotomy, neurectomy or rhizotomy), physical therapy, occupational therapy and the use of braces.[7] Botulinum toxin A (BoNT-A) is indicated for neurological conditions when spasticity affects a muscle or group of muscles and the patient does not respond pharmacotherapy or conventional physical therapy. This substance binds to terminal receptors in motor nerves and blocks neuromuscular conduction, thereby inhibiting the release of acetylcholine by the synaptic cleft.[8]

The first studies on treatment with (BoNT-A) in spasticity associated with CP were originally restricted to the treatment of patients with equinus foot. However, a child with CP rarely presents with an isolated spastic equine problem; There are usually problems at various levels (pelvis, hip, knee, and ankle). Many of the common walking patterns on the PC can only be properly treated if multiple muscles are treated simultaneously in a treatment session. Therefore, multilevel treatments are more appropriate. Because multiple muscles are injected simultaneously into a treatment session, multilevel treatments may require a higher total dosage when compared to single-level treatments for optimal treatment results. The treatment approach does not include standardized total dosages. Instead, the total dosage is defined by standard dosages by muscle group. The dose injected into a muscle depends on the muscle volume, the amount of spasticity and the degree of muscle involvement in the pattern of pathological gait.[9]

Rehabilitation of gait in children consists of improving joint alignment, increasing muscle strength (using electrical stimulation or strength training program,[10] reducing the symptoms of spasticity and preventing deformity.[6] The child also uses mobility assistance devices, which may be necessary as the child begins to walk.[11] In addition, neurofacilitation techniques, such as the technique established by B. Bobath, stimulate the central nervous system to establish normal movement patterns.[12] Another physiotherapeutic intervention is the treadmill training, where the children then attempts to walking on the slowly moving treadmill, eliciting the stepping movement, have shown improvements in lower extremity movements and gait pattern in children on cerebral palsy.[13] Physiotherapy intervention involves the joint use of orthotics when it is necessary to prevent or correct deformities. This is an external support (such as splints or suspenders or other different types of orthotics) for a weakened part of the body that also allows learning of motor skills, such as standing and walking.[14]

It is known that when conventional physiotherapy is complemented by a selective treatment for spasticity, such as injections of BoNT-A, as a consequence of increased muscle tone, it can be used, allowing a combined treatment and intended to provide improvement of motor ability and functional skills, and potentially, delay the need for surgery. A number of studies emphasize the importance of combined physical therapy with BoNT-A treatment, but due to the experience of knowledge about therapeutic contents and as different outcome measures, it is not possible to reach consensus on the content of the Physiotherapy after treatment with BoNT-A. A number of studies emphasize the importance of combined physical therapy with BoNT-A treatment. Because of the shortage of knowledge on therapy contents and the different outcome measures used in these studies, no consensus can be reached concerning the content of the physiotherapy programme after treatment with BoNT-A.[15]

Improving gait performance is an important functional goal in the rehabilitation of children with CP. Gait is compromised in 90% this population due to abnormal cortical excitability, excessive muscle weakness, abnormal joint kinematics and reduced postural reactions.[16] Deficient postural control limits motor development, compromising actions such as sitting, standing and walking.[17, 18] Indeed, falls are common among such children and constitute a limiting factor to functional dependence.[18]

The aim of this systematic review was to investigate from randomized controlled trials whether physiotherapy complemented with botulinum toxin A is effective in gait improvement compared to physiotherapy without use of botulinum toxin A in children with CP. The strengths of this study were: To investigate whether the performance of the physiotherapeutic intervention in the gait associated with the use of neuromuscular blockade in order to reduce

spasticity and to facilitate the improvement of gait pattern is more effective when compared to the physiotherapeutic intervention without the use of the pharmacological resource. The limitations of the study are directed to the non-investigation of drug administration in a detailed way, not being part of the objective of this review.

Evidence acquisition

Protocol and registration

The PRISMA indication (Preferential Report Items for Systematic and Meta-analyses) for conducting reviews of intervention studies was followed. This systematic review of the literature was also recorded in the PROSPERO database (CRD42017072738).

Identification and selection of studies

Searches were performed in the PubMed, Scielo, Physiotherapy Evidence Database Scale (PEDro), Cochrane Library, and OTseeker databases for relevant articles published between January 2000 and January 2017 using the terminology registered in the Medical Subject Headings of the U.S. National Library of Medicine (Mesh). The key words and their synonyms used were: "botulinum toxins, type A" AND "cerebral palsy" AND "gait." The titles and abstracts were analyzed by two researchers for the pre-selection of studies using the eligibility criteria. The pre-selected studies were then submitted to a full-text analysis by two independent researchers using the quality assessment criteria PEDro.

Inclusion criteria were: randomized controlled clinical trial or controlled clinical trial involving children or adolescents (<18 years of age) with spastic CP and diparesis having received BoNT-A in the lower limbs; physiotherapeutic intervention aimed at the functional improvement of gait; outcome measures, such as functional mobility, static/dynamic balance, gait performance, etc.

Exclusion criteria were: PASE study; cohort study; review study; pilot study; protocol study; cross-sectional study; longitudinal study; adolescents >18 years of age; without diagnostic of CP confirmed; clinical trials that do not have a group receiving BoNT-A and physiotherapy in lower limbs aimed at the functional improvement of gait; no control group.

Quality assessment

The pre-selected articles were evaluated and scored for methodological quality using the PEDro scale. The classification of the selected studies was performed by two independent researchers blinded to the objectives of the present review. In cases of a divergence of opinion, a third researcher made the decision regarding the score. For inclusion in the present review, all articles needed to achieve a score of 6 points or higher on the PEDro scale.

We conducted a sensitivity analysis through the Cochrane Collaboration tool for bias risk assessment of randomized clinical trials, to investigate the robustness of the results to each of the "Risk of bias" components by including only studies that were at low risk of bias for the most part. We used this information to guide our judgements on the quality of the evidence together with the PEDro quality assessment.

Evidence synthesis

Sixty-eight articles were retrieved from the databases searched. After the analysis of the titles, abstract and complete texts and the quality assessment using the PEDro scale (Table I),[19-22] only four articles met the eligibility criteria and achieved a quality score of 6 points or higher. Figure 1 displays the flowchart of the selection process.

Characteristics of studies selected

All four studies included were randomized controlled trials.[21-24] Three were randomized in a blinded manner based on a coin flip,[23] sealed envelopes[22, 23] or randomization by an independent researcher who was not involved in the selection process and had no access to clinical information on the children.[21] The mean PEDro score was 6.5. All studies

TABLE I.—*Methodological quality scores of articles selected for present review (PEDro scale).*

References	Random sequence generation	Concealed allocation	Similar prognosis	Blinding of participants	Blinding of therapists	Blinding of examiners	Outcome measures	Intention to treat	Inter-group comparisons	Variability and precision	Score (0-10)
Franki *et al*.[19]	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	6/10
Tedroff *et al*.[20]	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	6/10
Thomas *et al*.[21]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8/10
Van der Houwen *et al*.[22]	Yes	N	Yes	No	No	No	Yes	Yes	Yes	Yes	6/10

PEDro: Physiotherapy Evidence Database (www.pedro.org.au).

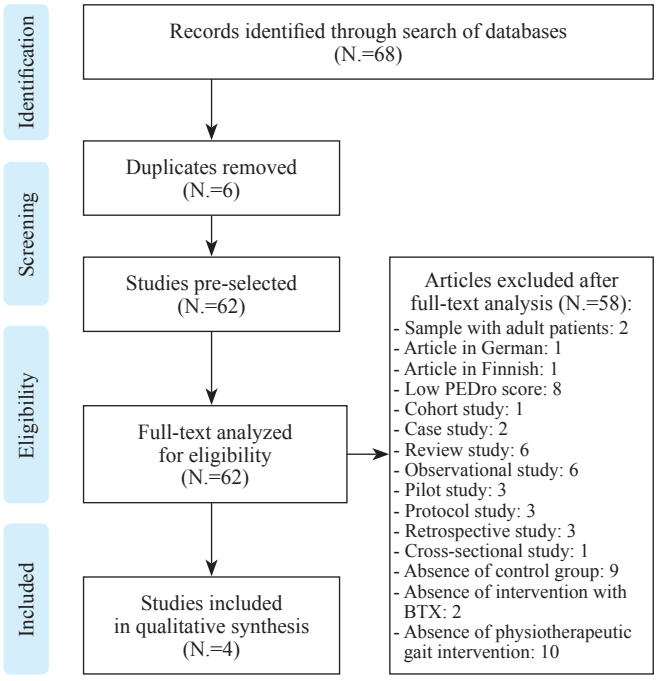

Figure 1.—Overview of article selection process.

reported variability and precision estimates and compared groups. The subjects and therapists were not blinded in any study. Although randomized controlled clinical trials are currently considered the gold standard in evidence-based medicine, the blinding of subjects and therapists is difficult in studies that involve interventional or surgical procedures.[25] Only two studies employed intention-to-treat analysis.[23, 24] All studies characterized the condition of the patients and described a similar baseline prognosis between the treated and control groups. Table II summarizes the risk of bias in the studies selected for the present systematic review, and Table III displays their main characteristics and outcomes.[19-22]

Discussion

The aim of the present systematic review was to evaluate scientific evidence regarding the effectiveness of physical therapy on gait following neuromuscular blockade in children with cerebral palsy in comparison to a placebo group submitted to physical therapy alone. A further aim was to determine the duration of the effects following the cessation of the physiotherapeutic intervention.

The use of BoNT-A in children with CP has become increasingly accepted as a viable alternative or complement to therapy for the treatment of lower limb spasticity. Moreover, the number of systematic reviews and meta-analyses has been growing steadily.[26] There is evidence of functional improvements following the administration of BoNT-A with regard to muscle tone in the lower limbs, range of motion and gait speed as well as the long-term maintenance of these effects.[27]

The incidence of severe adverse events related to treatment is low, especially in comparison to other invasive options for the management of spasticity, such as intrathecal baclofeno.[26] Only two adverse events of pain were reported among the children injected with BoNT-A. The first event was considered an adverse effect with no direct correlation with the use of BoNT-A; the patient complained of temporary pain in the right foot after the placement of the plaster cast, but continued the rehabilitation, despite not completing all activities proposed in the study.[23] The second event occurred in children who received BoNT-A and reported mild, self-limiting adverse events during the active phase on three (of 12) occasions, which included weakness, dysesthesia of the skin and pain at the injection site.[22] The absence of adverse events in the control group of each study confirms the association between the use of BoNT-A and possible side effects.

The dosage of BoNT-A varied. The dose was not reported in the studies conducted by Franki *et al.*[21] and Thomas *et al.*[23] Tedroff *et al.*[22] used a dose of 6 U/kg diluted to 50 U/mL per limb and divided into two doses with six-month interval between injections. Van der Howen *et al.*[24] used doses of 4 to 6 U/kg in a single dose. These doses are lower than that used in clinical practice, which ranges from 7 to 11 U/kg, increasing to 9±13 U/kg or 25.5 U/kg for children with diparesis.[26] It is not clear whether there is an optimal dose per muscle or per child to achieve a longer

TABLE II.— *Risk of bias in included studies.*

Study	Random allocation	Allocation concealment	Blinding of patients, personnel	Blinding of outcome assessors	Incomplete outcome data	Selective outcome reporter	Other
Franki *et al*.[19]	Low	Low	High	Low	High	Low	Low
Tedroff *et al*.[20]	Low	Low	High	High	Low	Low	Low
Thomas *et al*.[21]	Low	Low	High	Low	Low	Low	Low
Van der Houwen *et al*.[22]	Low	High	High	High	Low	Low	Low

duration of the response and minimize the occurrence of side effects. Boyd *et al.*[28] report the duration of the benefit for an average of 12.6 months following a single injection of The dosage of BoNT-A varied in the calf muscle at a dose of 7±11 U/kg. Tedroff *et al.*[22] report a reduction in the tone of plantar flexor muscles and an increase in the popliteal angle in comparison to baseline using 6 U/kg diluted to 50 U/ml per limb and divided into dose doses with a six-month interval between injections, with the benefits lasting 3.5 years.

In terms of age, it is theoretically better to treat younger children with The dosage of BoNT-A varied because contractures of the spastic limb tend to increase with age.[29] In three of the four studies included in the present review, the age for inclusion was four to 14 years.[21, 23, 24] In one study, The dosage of BoNT-A varied was used on children aged 11 months to one year and ten months.[22] Based on these studies, the medium and long terms effects of the benefits are greater when children are younger. Although only one or two outcome measures were altered in the studies analyzed, the results merit a more in-depth investigation.

Regarding the physiotherapeutic co-interventions, the combination of physical therapy and the dosage of BoNT-A varied enhances the effect of The dosage of BoNT-A varied on the lower limbs of children with CP.[21-24] Two studies[21, 23] used individual and group treatment plans. In the individualized program, the therapist used individual methods directed at a specific problem the child was having at that particular time. In the group program, the most common goals of children with spastic cerebral palsy were addressed and all children in the group were submitted to the same treatment. Franki *et al.*[21] defined individual problems based on the results of all evaluations, such as clinical examinations for the assessment of body and functional structures, three-dimensional gait analysis for the assessment of functional mobility and the Gross Motor Function Classification System. The objectives were discussed with the child's physiotherapist. The projects of the program resembled clinical practice and involved a mixture of individual techniques to reach the specific goal selected based on the child's individual needs. The group treatment program addressed more common goals in children with bilateral CP. Treatment was the same for all participants in the group and consisted of exercises to improve strength, selectivity and mobility, along with a set of functional exercises. Both the individual and group programs were performed by the children's personal physiotherapists, who agreed to follow the prescribed program precisely. The mean frequency for the individual and group programs was 3.9 and 3.7 times per week, respectively, and mean duration was 48.5 and 43.3 minutes per week, respectively. A total of 60 sessions were conducted (30 prior to the use of the dosage of BoNT-A varied and 30 after use) and the program was divided into two steps 10 weeks in duration.

Thomas *et al.*[23] used a series of plaster casts or braces based on the clinical indication of the child. The children in both groups received the same direct dose and same therapy protocol (six 60-minute sessions over a six-week period). The only difference was the therapy model (individual *vs*. group). A protocol with exercise suggestions was provided to each physiotherapist, who was encouraged to adhere to the theoretical framework addressing the main components of functional performance in a goal-oriented structure. Theories on motor learning, practice, incremental challenges and engagement were part of the theoretical framework, but the physiotherapist had flexibility with regard to selecting the activities that were adequate to the individual. Each participant in both groups was instructed to complete three individualized activities proposed by the physiotherapist at home three times per week as part of a home-based exercise program (18 sessions with no specific duration). Evaluations were performed 0 to two weeks prior to the dosage of BoNT-A varied injection, 10 to 12 weeks after the dosage of BoNT-A varied injection, and 26 weeks after the dosage of BoNT-A varied injection.

The study conducted by Tedroff *et al.*[22] only involved 15 minutes of stretching the gastrocnemius muscle performed by the caregiver of each child instructed by a community physiotherapist who was blinded to the evaluation process of the study. The frequency of both the dosage of BoNT-A varied and control (no use of the dosage of BoNT-A varied) was the same. The treatment phase (stretching and the dosage of BoNT-A varied) began when the children reached the motor mark of being able to stand up. The children began the study with a mean of 15.6±3.0 months in the control group and 16.7±5.1 months in the dosage of BoNT-A varied group. The children in the BoNT-A group received two injections in the gastrocnemius muscle with a six-month interval between injections. The treatment phase was concluded after one year. Evaluations were performed at baseline (prior to BoNT-A use) as well as after one and 3.5 years of follow-up.

Van der Howen *et al.*[24] performed intensive physical therapy in both the intervention and control groups, with three to five sessions per week for 12 weeks. Each session lasted 45 to 60 minutes. The treatment protocol was standardized and consisted of passive and active stretching, strengthening, functional mobility training and gait

TABLE III.—*Characteristics of studies included in systematic review (N.=4).*

Study	Participants	Type of drug and dose
Franki *et al*.[19]	N.=40 Age: 4-9 years Cooperation and understanding of verbal commands (GMFCS I, II, and III)	Not reported
Tedroff *et al*.[20]	N.=15 (6 BoNT-A, 9 controls) Unilateral or bilateral CP	Botox (Allergan) 6 U/kg Two doses with six-month interval
Thomas *et al*.[21]	N.=34 (6 GRP, 9 IND) Age: 4-14 years Spastic CP predominant Ambulatory (GMFCS I-III) Patients of CP BoNT-A health program BoNT-A in lower limb for treatment of spasticity Six weekly sessions of group or individual physical therapy	Botox (Allergan), dose not reported
Van der Houwen *et al*.[22]	N.=22 Age: 4-12 years Diparetic or hemiparetic spastic CP Muscle groups that affect mobility GMFCS I-IV Gait characterized by persistent knee flexion (>10°) Two or more muscles in need of BoNT-A injection Capacity to follow instructions Adequate knowledge of Dutch Ability to perform six large steps successfully Patient evaluated at Department of Medicine and Rehabilitation of VU Medical Center of University of Amsterdam	Botox (Allergan) 4-6 U/kg, single dose

GMFCS: Gross Motor Function Classification System; GMFM: Gross Motor Function Measure; BTX-A: botulinum toxin A; CP: cerebral palsy; PEDI: Pediatric Evaluation of Disability Inventory; ROM: range of motion; COPM: Canadian Occupational Performance Measure; CP QOL-Child: Quality of Life Questionnaire for Children with Cerebral Palsy.

training. A series of plaster casts or braces were also used based on the clinical indication of the child. The intervention group was evaluated at baseline as well as six, 12 and 24 weeks after multiple injections of BoNT-A (at least two sites per muscle at a maximum of 50 units per site). The control group was evaluated on two occasions, with a mean of 24.61 weeks between evaluations.

None of the studies included in this review found any differences at baseline between the groups analyzed in terms of the outcome measures. Franki *et al.*[21] found significant associations between age and changes in reaching functional goals, gait speed and other sub-items on the assessment scales. Older children were able to reach functional goals better and exhibited a change in Dimension D of the Gross Motor Function Measure (GMFM-88), but younger children demonstrated a greater change in gait speed, the timing of foot-off and time required for the Five-Times Sit-and-Stand Test. The GMFM-88 was used to assess functional progress after the intervention. This is a specific measure for cerebral palsy that is validated and reliable for the quantification of the development of motor skills. The GMFM-88 was the initial model, which was subsequently revised to make it more valuable to both the examiner and child, leading to the GMFM-66.[30, 31] Franki *et al.*[21] also report significant time effects on the Goal Attainment Scale (GAS) in the group submitted to more intensive therapy. The GAS was designed by Kiresuk and Sherman[32] for the assessment of the effectiveness

Procedure and injection site	Physiotherapeutic intervention	Outcome measures	Outcomes
Not reported	Individual therapy: individuals techniques similar to clinical practice aimed at specific objectives for child Group therapy: predefined set of exercises to improve strength, selectivity and mobility and set of functional exercises	Goniometry Modified Ashworth scale Modified Tardieu scale Motor selectivity scale Manual muscle test 3D gait analysis GMFCS GMFM-88 Timed Up-and-Go test Five-Times Sit-to-Stand Test Goal Attainment Scale	No significant changes in any outcome measure in either group
Gastrocnemius muscle Palpation to identify belly of muscle	Daily stretching of plantar flexor muscles (15 minutes) performed by community physiotherapist for both groups	Goniometry Modified Ashworth scale GMFM-66 PEDI 3D gait analysis	Reduction in muscle tone of gastrocnemius after 3.5 years and increase in ROM of knee after one year in BoNT-A group; no changes in gait, GMFM or PEDI
One or more lower limb muscles	Both groups submitted to goal-oriented functional performance program (functional reinforcement, balance, motor control, fitness and agility); Sessions involved warm up and cool down, with reviews of exercises to be performed at home	COPM Edinburgh visual gait score Pediatric Reach Test 1-Minute Fast Walk Test GMFM-88 CP QOL-Child	Significant improvements in performance and satisfaction on COPM and changes in gait quality in both groups
Injection sites determined through palpation of belly of muscle and placement of needle verified by lengthening or electrical stimulation of muscle	Standardized treatment protocol: passive/active stretching and strengthening of plantar flexors, strengthening, functional mobility and gait training	Electromyography Video-assisted kinematic gait analysis	No significant improvement in activation of muscles tested during gait
Target muscle identified through gait analysis and clinical examination; Possible muscles: psoas, medial and lateral hamstrings; hip adductors; rectus femoris; gastrocnemius, soleus and tibialis posterior	Used of serial casts and/or brace 45-minute sessions 2-5 times per week for 12 weeks		

of a program based on whether the individual goals of the patient are met. Besides providing a semi-quantitative (ordinal) result regarding the attainment of goals, the GAS also provides potentially useful qualitative information on the patient's priority treatment goals. For the specific evaluation of gait, Franki *et al.*[21] used three-dimensional gait analysis as the primary measure, acquiring information on kinematics, kinetics and spatiotemporal variables. However, no significant interactions were found between the types of programs proposed.

Tedroff *et al.*[22] used the GMFM-66, Pediatric Evaluation of Disability Inventory (PEDI), modified Ashworth scale and goniometry as the outcome measures. The goniometric analysis revealed that the BoNT-A group exhibited a reduction in the popliteal angle, demonstrating an increase in the range of motion of the knee. Moreover, the modified Ashworth scale revealed a reduction in muscle tone of the plantar flexor muscles in the BoNT-A group after one and 3.5 years of follow-up. The Ashworth scale and its modified version are considered valid assessment tools for the measurement of muscle tone but have not been tested with regard to reliability on children with CP.[33] Both groups in the study (with and without use of BoNT-A) demonstrated improvements on the GMFM-66 and all subscales of the PEDI. The PEDI is used for a standardized assessment of functional skills in children and is administered to parents or caregivers for the determination of how a child functions in daily life.

Thomas *et al.*[23] used the Canadian Occupational Performance Measure (COPM), which is widely used for individualized results centered on patients in pediatric rehabilitation and reflects the focus of the intervention on the goals and priorities of the child and family. The COPM has adequate content, construct and criterion validity for children with CP who have received BoNT-A, sensitivity to change and high test-retest reliability.[23] Another outcome measure employed was the Edinburgh Visual Gait Score, which is used to measure the quality of gait through a visual score that ranges from 0 (best) to 68 (worst). This measure has good reliability, reproducibility, sensitivity to change and criterion validity with a gait analysis system. The study groups who received either individualized or group physical therapy demonstrated clinically significant improvements in performance and satisfaction on the COPM as well as a change in gait quality. No significant differences were found regarding the other outcome measures, such as the quality of life questionnaire for children with cerebral palsy (CP QOL-Child) and the One-Minute Fast Walk Test.

Van der Howen *et al.*[24] used surface electromyography (EMG), which consisted of the placement of electrodes on the medial gastrocnemius, rectus femoris and medial hamstrings bilaterally and evaluated during gait. Video recordings were also made on the frontal and sagittal planes while the child walked barefoot at a comfortable pace (with or without a gait assistance device) along a 10-meter track. Muscle activation patterns during gait can be measured using surface EMG, enabling the determination of an increase in involuntary muscle activity as well as the evaluation of abnormalities in the EMG amplitude or pattern. However, amplitude depends on different factors, such as thickness of the subcutaneous tissue and the placement of the electrodes.[24] The authors report no changes in the muscles analyzed in the BoNT-A group, with the exception of the medial gastrocnemius, which deteriorated significantly in comparison to the control group.

Strengths and limitations of the study

The present systematic review has strong points and limitations that should be addressed. The strong points were the comprehensive search strategy, the absence of selection bias, since the reviewers were blinded to the journals, authors and results of the studies, and the inclusion of only randomized controlled clinical trials. However, the results of this review are potentially affected by the small estimate of the effect size for the determination of clinical significance, as only four studies met the eligibility criteria and had adequate methodological quality (six or more points on the PEDro scale). There was limited scope for meta-analysis because of the range of different outcomes measured across the small number of existing trials. Few studies have used the same type of intervention and comparator, with the same outcome measure.

Conclusions

The present systematic review is the first to investigate the effectiveness of physical therapy combined with the use of botulinum toxin A on gait in children with cerebral palsy. Therefore, this study offers a view on the increase in the therapeutic effectiveness of BoNT-A on the lower limbs when used in conjunction with a physiotherapeutic intervention, with improvements in mobility, gait pattern, range of motion and spasticity, which are maintained after the end of the physical therapy protocol. The results suggest that both short-term physiotherapeutic interventions and high-intensity interventions have positive effects on children with CP who use BoNT-A. It should be stressed, however, that it is important to perform a clinical evaluation combined with goals and quantitative measures that are viable for small children, who may be too young or unable to cooperate during some evaluation procedures and therefore cannot provide the knowledge necessary to detect clinically significant changes during a physiotherapeutic intervention.

The findings of the present review suggest that the use of BoNT-A for the treatment of lower limb spasticity in children with CP has become increasingly accepted as a viable alternative or complement to physical therapy and seems to be a useful option in the interdisciplinary care of this population, especially when children are young, so that contractures can be avoided, and the motor potential can be optimized. The findings also demonstrate the need for further randomized controlled clinical trials with high methodological quality on the use of botulinum toxin A for the treatment of lower limb spasticity in children with cerebral palsy.

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