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ORIGINAL ARTICLE

Cerebral palsy - lower limbs: rehabilitation

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DESCRIPTION OF THE EVIDENCE COLLECTION METHOD

This study revised articles from the MEDLINE (PubMed) databases and other research sources, with no time limit. To do so, the search strategy adopted was based on (P.I.C.O.) structured questions (from the initials "Patient"; "Intervention"; "Control" and "Outcome". As keywords were used:

Question 1: cerebral palsy AND (stretching OR muscle spasticity OR muscle stretching exercises) AND (physical therapy modalities OR rehabilitation);

Question 2: cerebral palsy AND (rehabilitation treatment OR motor activity) AND home care;

Question 3: cerebral palsy AND strength training AND lower extremity AND (gait training or gait);

Question 4: cerebral palsy AND (motor skill learning OR motor learning) AND physiotherapy;

Question 5: (cerebral palsy OR CP OR diplegic OR spastic diplegia OR little disease OR hemiplegia OR hemiplegic) AND (function OR movement) AND (feedback OR visual perception OR visual OR biofeedback);

Question 6: (cerebral palsy OR CP OR diplegic OR spastic diplegia OR Little Disease OR hemiplegia OR hemiplegic) AND (orthopedic equipment OR orthotic devices) AND (gait OR walking);

Question 7: (cerebral palsy OR CP OR diplegic OR spastic diplegia OR Little Disease OR hemiplegia OR hemiplegic) AND (walkers) AND (energy);

Question 8: (Cerebral Palsy OR Cerebral palsy spastic diplegic OR hemiplegia OR quadriplegia) AND (wheelchair OR self-help devices);

Question 9: Cerebral Palsy AND (Bicycling OR Ergometry);

Question 10: Cerebral Palsy OR Disabled Children) AND (Electric Stimulation Therapy OR Electric Stimulation) AND (Gait OR Gait Disorders Neurologic);

Question 11: (Cerebral Palsy OR Cerebral palsy spastic diplegic OR hemiplegia OR quadriplegia) AND (wheelchair OR self-help devices);

Question 12: (Cerebral Palsy OR Quadriplegia OR Cerebral Palsy, Spastic, Diplegic OR Hemiplegia) AND (Virtual Reality);

Question 13: (Cerebral Palsy OR Quadriplegia OR Cerebral Palsy, Spastic, Diplegic OR Hemiplegia) AND (Robotic-Assisted OR Gait Training OR Treadmill Training OR Walking).

With the above keywords crossings were performed according to the proposed theme in each topic of the (P.I.C.O.) questions. After analyzing this material, therapy narrow articles regarding the questions were selected and, by studying those, the evidences that fundamented the directives of this document were established.

LEVEL OF RECOMMENDATION AND EVIDENCE:

A: Strong consistency experimental or observational studies.

B: Fair consistency experimental or observational studies.

C: Case reports (uncontrolled studies).

D: Opinion lacking critical evaluation, based on consensus, physiological studies or animal models.

OBJECTIVES:

Offering information regarding the effectiveness of available auxiliary resources for the treatment of children with Cerebral Palsy.

PROCEDURES:

Analyzing the main resources that help in the process of promotion and rehabilitation of functional skills.

CONFLICTS OF INTERESTS:

There are no declared conflicts of interests.

INTRODUCTION

Cerebral Palsy (CP) is a movement and posture disorder consequent to the non-progressive immature or in development brain lesion, which provokes clinical manifestations. The motor disorders may be accompanied by cognition, communication, perception, and/or epilepsy disorders[1] **(D)**.

Musculoskeletal and movement disorders are the main secondary alterations of cerebral lesion. These alterations may result in postural, balance and gait deficits, as well as the child's functional performance impairment[1] **(D)**.

It is estimated that in underdeveloped countries the prevalence is higher than in developed countries, being observed indices of 7:1000 borne alive. In Brazil, the estimated CP data are of 30.000 to 40.000 new cases per year[2] **(C)**.

CP diagnose is, basically, clinic, and a rigorous evaluation is indispensable for better follow-up, maintenance and treatment of the diseased child.

In the literature there are a few motor function classification scales for CP children, such as the GMFCS (Gross Motor Function Classification System), supplied by the CanChild Centre of Canada. This is the study center responsible for specifying the scale for evaluation of the CP child, being that this scale assesses the child's functional mobility in five increasing gravity levels, based in the voluntarily initiated movement, and with particular emphasis in sitting and walking:

- Level I: Optimal trunk control and independent gait;
- Level II: Good trunk control and gait limitations;
- Level III: Good trunk control and gait dependent on locomotion auxiliary devices;
- Level IV: Poor trunk control and gait dependent of auxiliary devices and supervision with possible use of powered wheelchair;
- Level V: Limited trunk control and locomotion with wheelchair.

This scale is used in the assessment of individuals aged up to eighteen years, being that in premature children the corrected age should be considered. The classification is ordinal, with no intention that the distances between levels are considered equal, or that CP children be distributed, equally, within the five levels[3] **(B)**.

The physical rehabilitation program for CP children must count with the intervention of a multidisciplinary team, each one of the different professionals contributes with their expertise to minimize the difficulties presented by their patients, making them improve their performance in their activities of daily life (ADL) and activities of practical life (APL), thus overcoming their limitations and acquiring greater autonomy.

We cannot think of rehabilitation methods without binding the available interventions for the CP child and perfecting their treatment. However, in rehabilitation, specially in the fields of Physical Therapy and Occupational Therapy, questions arise along the course of clinical practice, that direct the search for evidence-based practice.

1. Is conventional muscle stretching the best technique for gaining amplitude of movement after application of type A botulinum toxin (BTX/A) in children with cerebral palsy?

Children with diagnosis of cerebral palsy, of the type diparetic spastic, of both genders, aged two to eight years, ambulatory, with LLLL spasticity, followed-up for twelve months, were submitted to the application of Type A botulinum toxin (BTX/A), local anesthetic cream, intranasal midazolam, dosage of four to eight units kg -1 and maximum of twenty units per site in the gastrocnemius muscle and after two months used AFO. Those were compared to children submitted to the use of lower limb serial casting with neutral position of ankle for a two-week period with a four-week interval and a traction for serial casting supported dorsiflexion for another two weeks, totalling a six-week period. Being both capable of producing, clinically, an improvement in muscle spasticity, improvement in muscular balance which eases gait and gross motor function in CP children aged two to eight years, ambulatory. Both interventions were evaluated by the parents with a satisfaction questionnaire, evidencing the preference for BTX/A due to the application in single dose and to the cast-provided inconvenience, mainly for bathing the children[4] **(B)**.

Children with CP diagnosis and uni or bilateral impairment, aged between four and twelve years, both genders, with up to Level IV GMFCS, ambulatory, with gait characterized by knee flexion in medium support, with spasticity on two or more muscular groups were divided into two groups. The first one performed low intensity physical therapy, one to two times a week, during thirty to sixty minutes; the second one performed multi-level BTX/A application in the psoas, ischiotibial, adductors of the hip, straight thigh, gastrocnemius, soleus, and posterior tibial muscles, being that the target muscle identification for the injections was based in gait analysis and clinical exam, and the drug was administered to patients under general anesthesia. The injection sites were determined by palpation of the muscle belly and the needle insertion was verified either by stretching or by electrical stimulation of the muscle, in at least two sites per muscle belly, up to a maximum of 50 U/site, with a dose of 4-6 U/kg per muscle group. The maximum total dose was 25 U/kg for children aged up to five years, and 30 U/kg for children older than six years, with maximum recommended dose of 600 U. The dilution of 50 U/mL of NaCl 0,9% solution was used, followed by intensive physical therapy three to five times a week with duration of forty-five to sixty minutes per session, during twelve weeks, starting a week after application of BTX/A. After physical therapy, in random manner, a few children made use of orthoses or serial casting favouring knee extension and dorsiflexion. Those presented expressive improvement in knee extension and dorsiflexion. They presented expressive improvement of knee extension during medium support, terminal support and hip rotation during the terminal swing phase, improvement of gait general quality, and there was reduction in muscle shortening and spasticity. Therefore, the contraindication in the application of BTX/A in children with muscular shortening should not be considered[5] **(B)**.

Children with CP diagnosis and uni or bilateral impairment, average age of sixteen months, were followed-up for a period of one year and reassessed at the age of three years and six months. One of the groups received two BTX/A applications to the gastrocnemius muscle, with a six-month interval between applications, with a dosage of 6 U/kg, diluted in 50 U/mL. The injection was divided in four sites of the muscle, using palpation to identify muscle bellies. After the application, these children were submitted to a fifty-minute daily muscular stretching program, performed by their parents after orientation from a community physical therapist, for 229 sessions over a one-year period. Another group performed daily muscular stretching at home on the gastrocnemius and soleus muscles for fifteen minutes, during 237 days on the first year, performed by the parents after orientation from a community physical therapist. AOM of the knee was significantly increased in children who had BTX/A and daily muscular stretching over a one-year period, but was decreased in knee and anlke joints in the group that had solely the daily muscular stretching over a one-year period, after the age of three years and six months. The early treatment of children with spastic CP using BTA/X combined with daily muscular stretching over a one-year period decreases muscle tone and development of contracture in the gastrocnemius muscle favouring the improvement of knee extension and ankle dorsiflexion[6] **(B)**.

Another study was performed on CP children, severe mental retardation, spastic and/or dystonic, with tension on the ischiotibial muscles, aged from four to thirteen years, of both genders. The participants received four treatment sessions, with four different procedures, composed by five repetitions of stretching each, with a twenty-four-hour interval from one to the next. Procedures were determined as A, B, C, and D, using electromyography (EMG) on the ischiotibial muscles before and after each treatment condition. Group A performed ten seconds of passive stretching, Group B performed thirty seconds of passive stretching, Group C used a heat pack for twenty minutes, followed by ten seconds of stretching, and Group D a heat pack for twenty minutes, followed by five times thirty seconds of passive stretching. The ischiotibial muscle stretching was performed with the patient in supine position with hip and knee flexed at 90° as initial position, the other leg positioned in the neutral position. As standardization of stretching strength, a hand dynamometer was used above the malleolus and the amount of strength was individually determined, according to the resistance felt on the final range of knee passive extension for each subject. The same strength was applied on all four procedures. The heat before stretching results in greater increase in the extensibility of the ischiotibial muscles, compared, solely, with stretching. Stretching produces a higher degree of relaxation regardless of thermal treatment. When it is sustained for thirty seconds with five repetitions it leads to a higher degree of muscular relaxation than when sustained for ten seconds[7] **(B)**.

A research using the electronic databases MED-LINE, PUBMED, DARE, BMJ updates, and TRIP, published in English between 1990 and May 2008, compared BTX/A with placebo, other pharmacotherapies, or a combination of BTX/A with non-pharmacological therapies. Only studies with CP children were included. The members of the technical review panel led by the first Author (ML) in an independent manner, reviewed and classified on RCT classes I and II, are included in this review. Each essay was independently evaluated by two reviewers. This review, which summarized classes I and II of tests with 360 children with spasticity on lower limbs shows growing evidence that BTX/A is effective in spasticity reduction, pain relief, contracture prevention, in CP children. BTX/A is a great advancement in the treatment of spasticity. When combined to surgical and non-pharmacological intervention and to an interdisciplinary team, it is the best treatment approach for CP children. Future debates must concentrate in optimizing injection schemes and pharmacoeconomics matters, eventually[8] **(C)**.

Recommendation

Muscular stretching in children with Cerebral Palsy of the type tetraparetic, hemiparetic or diparetic, spastic and/or dystonic, with uni and bilateral impairment, spastic and/or dystonic of both genders, aged one year and four months to thirteen years, with up to level IV GMFCS, ambulatory, combined to BTX/A application up to a maximum of 20-50 U/site, with a dose of 4-8 U/kg per muscle group, being the maximum total dose 25 U/kg for children of up to five years, and 30 U/kg for children over six years, with maximum recommended dose of 600 U, with dilution of 50 U/mL of NaCl 0.9%, used in the psoas, ischiotibial, adductors of the hip, straight thigh, gastrocnemius, soleus, and posterior tibial muscles, followed by intensive physical therapy three to five days a week, in sessions of forty-five to sixty minutes over a one-year period, starting one week after the application of BTX/A, promotes a higher degree of relaxation and extensibility of the muscles when sustained for thirty seconds and five repetitions, regardless of thermal treatment, an improvement in muscular spasticiy, improvement in muscular balance, improvement in AOM easing gait and gross motor function in children with Cerebral Palsy **(B and C)**.

2. Is conventional rehabilitation, on the collection of orientations to caregivers for home exercises/activities, effective for children with cerebral palsy when compared to those not oriented to perform home exercises?

The home physical exercises program oriented to parents and caregivers of children with cerebral palsy and followed-up by therapist, performed with twenty children with cerebral palsy, aged between seven and thirteen years, with no AOM limitation, capable of understanding and executing simple commands, for sitting and standing exercises in an independent manner, and climbing steps indicated for daily performance in series of three repetitions of each exercise per minute and with progressive increment, and rest of one minute between series for six weeks, is effective for maintaining gains after the end of intervention, and improvement regarding functional balance in the activities of daily life[9] **(B)**.

The performance of home exercises for muscular strengthening in young people aged between eight and eighteen years showed improvement in gait pattern for children with cerebral palsy, according to study conducted with a six-week intervention with therapist orientation and individualized adjustment of initial load and its speed progression according to each child's evolution when compared to control group. In randomization, the experimental group presented worse assessment regarding motor skills[10] **(B)**.

Recommendation

There is no significant functional improvement in duly oriented home activities for children with cerebral palsy[9,10] **(B)**.

Anyway, the fact that patient and family extend exercises beyond the walls of the rehabilitation centers brings benefits, either by the structured manner of performing muscular strengthening exercises with a tendency of progressive increment of load for improvement of gait in series with eight to ten repetitions of exercises for LLLL strengthening, extensors of the knee and hip and plantar flexors, for six weeks in children aged between eight and eighteen years; or even sitting and standing acitivities with repetitions over one minute, followed by one minute of rest for children between four and fourteen years and GMFCS between I and IV that present independent gait ability, even with the use of gait auxiliary devices for the task of climbing and descending steps performed daily, brought discrete improvement in body balance for the performance of functional activities when performed, daily, for six weeks[9,10] **(B)**.

3. Is LLLL muscular strengthening, combined with gait training, effective on CP children?

On children with CP of the dype diplegic spastic aged four to twelve years, GMFCS II to III, submitted to muscular training within a minimum period of five weeks, performing isotonic, isokinetic exercises, with gradual load increment, three times a week, with two series of ten repetitions, for sixty minutes, it is observed good evolution regarding increase in strength of extensors of the hip and there was no significant alteration in spasticity, such results last after six weeks from training. Muscular training was significant in the improvement of gait, especially, in speed and step length. When this training is compared to conventional physical therapy, neuro-propioceptive facilitation, gait training and non-specific conventional exercises, the results become more evident[11] **(B)**.

Also, when the strengthening training is increased for weeks, it is possible to observe expressive improvement in muscular participation of dorsiflexors during the initial contact and the swing phase during gait in children with CP[12] **(C)**.

Over an eight-week period, three times a week, with one hour and a half per session, it can be observed the improvement in strength of the extensors/flexors of the hip, and flexors of the knees musculature[13] **(B)**.

Recommendation

There is controversy regarding improvement in gait training provided by the specific muscular strengthening program[14] **(B)**. Muscular training has no adverse effects, especially, in the increase of muscle tone, on the contrary, the strengthening by itself is beneficial for CP children and is sustained for six weeks[1,3] (**B**).

The CP child aged between nine and fifteen years, GMFCS I and II, who can follow simple commands, benefits from muscular strengthening against gravity and resistance, three series of ten repetitions, over a period of eight weeks, three times a week, during one hour and thirty minutes per session, especially, for extensors/flexors of the hip and flexors of the knees musculature for functional improvement of gait[14] **(B)**.

4. Does continuous physical therapy interfere in the motor learning when compared to intermittent physical therapy on CP children?

CP children, when submitted to Bobath intervention in continuous treatment two times a week, present greater benefits compared to intermittent therapy once a week, even with home intervention by caregivers. The proportional average of change in motor development was greater in the intensive group than in the intermittent group, when compared with the following variables: age, complications at birth, and mother's educational level. The effect of imbalance in those variables placed the intensive group at a disadvantage compared to the intermittent group, it was observed that mothers with no higher education tend to be less capable of participating in the child's stimulation. The type of intercurrence at birth combined with other comorbidities may influence the outcomes when submitted to continuous or intermittent interventions, when those are related to the frequency in therapy, therefore caregivers must question those benefits to the child with the professional[15] **(B)**. Adherence to treatment in the continuous group is greater in younger children with milder GMFCS, because changes in environment, transportations, frequency, and rejection to treatment are factors that limit rehabilitation in more severely afflicted children, especially physical therapy applied in different manners, continuous or intermittent, in children with CP is valid, because there is significant data regarding motor improvement[16] **(B)**. The outcome of muscular strengthening related to motor performance persisted after six months and was more significant in the population that performed intermittent therapy compared with the intensive group, even though also improved. On the other hand, motor function was more effective in children who participated in the intensive group[17] **(A)**.

Recommendation

There is no statiscially significant difference in the use of continuous or intermittent physical therapy, both in CP with mild disease, or more advanced disease[16,17] **(B)**. Intermittent and continuous therapy are effective for CP children, as long as the therapist selects the sample regarding the factors associated with the disease. For children with milder affliction, the continuous therapy is more effective, and for more severely afflicted children, the intermittent is more effective, because environmental aspects may influence their evolution[16] **(B)**.

5. Does the use of biofeedback provide improvement in gait of children with cerebral palsy?

In children with CP of the type hemiparetic or diparetic, who present independent gait, the use of biofeedback in plantar dorsiflexors and flexors for thirty minutes a day, during ten days, shows a significant decrease in triceps muscle of calf tone ($p < 0.000$), maintained after thirty days of treatment. Regarding amplitudes of movement, biofeedback shows to be effective in the improvement of active dorsiflexion, which was maintained during the second month and had a slight decrease in the third month. There was a decrease in the score ($p < 0,05$) of the *Clinical Gait Assessment*, also showing an improvement in this aspect. The kinematic parameteres of gait also showed improvement with the use of biofeedback. There was an increase in speed, cadence, and step length ($p < 0,05$), which was sustained or increased in the three months after treatment[18] **(B)**.

Recommendation

The use of biofeedback in plantar dorsiflexors and flexors for thirty minutes a day, for at least ten days, promotes the improvement of amplitude of movement of the ankle, quality of spacial-temporal parameters of gait in children with CP of the type hemiparetic or diparetic with independent ambulation. Most of the papers on biofeedback study populations with Encephalic Vascular Accident sequelae. For CP there is one single paper[18] **(B)**. Therefore, there are still doubts regarding the effectiveness of its use as a supplemental therapy for this population.

6. Is the use of lower limb orthosis effective for the improvement in gait of children with cerebral palsy?

In children with CP of the type hemiparetic, the use of *Ankle foot ortheses* (AFO) for six to twelve hours a day, during three months, demonstrated in gait analysis, a significant increase in dorsiflexion during initial contact ($p = 0.0001$), however, with a decrease in dynamic amplitude of movement of the anke ($p = 0.0001$) and in the peak of strength of the ankle ($p = 0.03$). Regarding spatial-temporal gait parameters, step width and length were significantly greater ($p = 0.0001$), the cadence was expressively decreased ($p < 0.002$) and speed was not changed with use of AFO. Energy consumption (mL o2/kg/m) during gait was decreased in twenty-one children and did not change, or increased in eight children, showing one out of two children that use AFO benefits from its use, with lower energy consumption[19] **(B)**.

In children with CP of the type diparetic, the continuous use of AFO during one month showed reduction in amplitude of movement of the ankle and in the peak of strength of the ankle, an increase in dorsiflexion during initial contact and at the moment of plantar flexion in impulse. The spatial-temporal parameters of gait showed significant differences on the averages, showing increase in step length with the use of orthosis. There was no significant difference in cadence, steps/minute, gait velocity, and kinetic and kinematic of hip and knee joints[20] **(B)**.

When assessed, specifically, the motor skills, walk/run/jump, with the *Gross motor function and performance* (GMFM), there was no significant change in score with the use of AFO in children with hemiparetic CP[19] **(B)**. In CP children that used *Dynamic Ankle foot ortheses* (DAFO) during four hours a day, over the period of one month, there was improvement in the function in ability to walk, run and jump in GMFM, with significant increase in the scale score. The group of twenty-three children obtained a 19.9 average when not using DAFO and 26.4 when using the orthosis[21] **(B)**.

In children with CP of the type diparetic who present squatting gait, the use of articulated and dynamic orthosis during four weeks showed to be effective in the increase of gait speed and step length, however, there was a decrease in cadence with the use of both types of orthoses. There was also an increase in dorsiflexion during initial contact and terminal contact. There was no improvement in the children's motor function in the abilities on foot, walking, running and jumping of the scale[22] **(A)**.

There is no statistically significant difference with the use of serial splinting in the spatial-temporal parameters of gait, speed in meters per second, cadence in steps per minute, and kinematic, maximum dorsiflexion in degrees during single support and swing phase, in CP children, three hemiplegic and six diplegic, aged over five years[23] **(B)**.

Recommendation

The use of AFOs and DAFO is recommended for the improvement of a few kinetic and kinematic parameters of gait and decrease of energy consumption in children with hemiparetic and diparetic CP, who present equine or squatting gait. The indicated period of use is four to eight hours a day, for at least one and a half months, so that a beneficial effect can be observed in gait. With the use of orthosis, there is an increase in dorsiflexion and step width and length, as well as a decrease in energy consumption, cadence, peak of strength, and dynamic amplitude of the ankle. The use leads to the decrease in dynamic amplitude of movement of the anke [20,21] **(B)**, and in ankle strength[21] **(B)**. Regarding motor function, there is no evidence of improvement in the motor performance of children with the use of AFOs or DAFO in the analyzed articles[19-23] **(A, B)**.

7. Which walker promotes decreased energy consumption during gait in children with cerebral palsy?

In children with CP of the type diparetic who present ambulation with aid, posterior and anterior walkers showed a similar energy consumption. However, one study demonstrated lower energy consumption, oxygen consumption in mL/kg/min, with the use of posterior walker. In this study with ten children with diparetic CP, gait test was performed during five minutes and the posterior walker showed to be more effective in the decrease of oxygen consumption (ml/kg/min) in children aged seven to twelve years with CP diagnosis. Average speed and cadence were similar with both types of walkers in this study[24] **(B)**.

Another study, conducted in ten children aged eigth to seventeen years, showed that there is no statistical difference in energy consumption between anterior walker, average 15.8 mL/kg/min, and posterior walker, average 16.5 mL/kg/mim. No difference was observed, neither in heart reate, average 147 in both groups, nor in gait speed, average 27.2 m/min with anterior or posterior walker (28.8 m/min)[25] **(B)**.

Different study containing ten children with spastic diplegia, aged five to eighteen years, with GMFCS three or four, did not present statistically significant difference in the energy consumption measured in beats per meter, anterior = 2.31 and posterior = 1.70, and in heart rate, anterior = 134.73 and posterior = 135.26, of the children. There was also no difference in the spatial-temporal parameters of gait between posterior and anterior walkers: both walkers had average cadence in steps per minute, anterior equal to 77.05 and posterior equal to 69.79, speed in meters per second, anterior equal to 0.42 and posterior equal to 0.35 and step length in meters similar. Therefore, there was no difference between posterior and anterior walkers in energy consumption and spatial-temporal parameters of gait in children with CP, diparetic, aged five to eighteen years[26] **(B)**.

These data corroborate with Konop et al., showing that there is no difference in average energy consumption in beats per minute when comparing both walkers, anterior equal to 2.0 meters and posterior equal to 1.6 meters, as well as in spatial-temporal parameters of gait, speed, cadence, and step length, in children with CP, diparetic, aged eight to eigtheen years[27] **(B)**.

Recommendation

Posterior and anterior walkers promote similar energy consumption, oxygen consumption in mL/kg/min, and heart beats per meter, in children diagnosed with CP of the type diparetic, capable of deambulation with the use of walker, aged between five and eighteen years. Therefore, both are recommended as gait auxiliary devices for this population. This benefit is not found in children with spastic diplegia [26] **(B)**.

8. Is the use of wheelchair important to ease the mobility of children with cerebral palsy?

Cerebral palsy is a disorder of movement and posture, being frequent cause of motor impairment in infancy.

Such problems tend to affect almost all of the aspects in these children's lives.

Auxilliary devices are tools designed to improve function in people with impairment or to reduce barriers to increase their independence, participation, and quality of life.

Children accompanied by their mothers were submitted to a questionnaire, in which the mother was interviewed first and then the child, separately. The children were eight to fifteen years old, being six boys and nine girls. It was observed that in spite of the advantages brought by the use of wheelchair and other devices, the patients not necessarily used them at home. Of the thirty-eight devices reported, walkers, WC, tricycles, orthoses, computer devices among others, fifteen were used every day or twice a week, eleven only outside and twelve were abandoned.

A little over half of the children did not use the devices at home, some used a few of them and only two used all prescribed devices. All of this is due to the childrens' reluctance, mothers' perception and physical barriers[28] **(B)**.

It is observed that the use of wheelchair is connected to the environment where the patient is. The parents of 636 children, 355 boys and 281 girls aged two to twelve years, answered a questionnaire about their children's mobility, at home, at school, and in the community, while therapists classified these children in GMFCS.

It was possible to observe that the children:

2 to 3 years old:

- Level I: 90% walked independently at home, at school were 89% and in the community 74%;
- Level II: 64% locomoted on the ground at home, while 50% walked with support at school and 40% used WC and 20% were carried by an adult, there was report that the children also walked independently on the three environments;
- Level III: 94% locomoted on the ground at home, 50% walked with support and 33% locomoted on the ground at school, being that in the community 61% used WC and 33% were carried by adults;
- Level IV: at home 67% locomoted on the ground and at school another 31% also locomoted this way, but in the community 67% were pushed on the WC, at this level they were also carried by adults on the three environments;

- Level V: 91% were carried by adults at home, at school 69% used WC and 31% were carried by adults and in the community 86% used the WC.

4 to 12 years:

- Level I: all walked independently on the three environments;
- Level II: 87% walked independently at home, at school they were 79% and in the community 56%;
- Level III: 47% locomoted on the ground at home, 58% walked with support at school and 43% were pushed on the WC in the community;
- Level IV: 46% locomoted on the ground at home, at school 39% were pushed on WC and 24% used powered WC and in the community 62% were pushed in the WC and 23% used powered WC;
- Level V: 39% were carried by an adult at home, while 44% were pushed on the WC, 81% of them were also pushed on the WC at school and in the community they were 93%;

It is observed then that the use of WC is very important in external environments.

A few impediments would be accessibility and financial conditions of patients[29] **(B)**.

Recommendation

The use of WC is recommended to ease the mobility of children with CP, since in the school environment, especially, the enthusiasm in participating of activities, interacting, and improving their performance promotes its greater use[28] **(B)**.

However, it should be remembered to value the children's active participation regarding this auxiliary device, as well as any other, seeking to increase the quality of their involvement and that of their caregivers, since even there having been perception of the advantages of using such devices, many times they are abandoned[28] **(B)**.

Accessibility and the needs of caregivers must also be considered, due to their being great impeditives for the greater use of these devices. Another important aspect to be highlighted is the need of continuous follow-up and assessment of such devices in order to help in difficulties in their use, prevent injuries, and have safe transportation[29] **(B)**.

9. Does the stationary bicycle help motor function and muscular strength of children with cerebral palsy?

The stationary bicycle contributed to the improvement in muscular strength and locomotor resistance, favouring improvement in gait and gross motor function. Being performed in slow speed, 30 degrees/sec, there was greater recruiting of knee flexors while in faster speed, 120 degrees/sec, the greatest recruiting was on the knee flexors. However, it showed to be more effective in children with CP of the type diparetic spastic, with the highest level of motor function, GMFCS level I, with score for the GMFM-66 = 100%. These children attained the ability of performing cycling with maximum load during the first session, being preceded by an active stretching period of five to ten minutes. The average resistance gain during the whole period of intervention approached 74% of body weight. However, children with a lower level of gross motor function, GMFCS level III, with score for GMFM-66 = 47.5, did not develop this ability[30] **(B)**.

Recommendation

The use of the stationary bicycle, after initial stretchings for five to ten minutes, performed in thirty sessions three times a week, for twelve consecutive weeks, with duration of thirty to forty-five minutes, with progressive load increment according to body weight, being 10 lb (Kg = 4.535) as the minimum resistance and 100 lb (Kg = 45.359237) as maximum resistance, in children with CP of the type spastic diparesia, aged between seven and eighteen years, with GMFCS up to motor level II, contributes in a significant manner to the improvement of muscular strength and resistance, as well as of motor function[30] **(B)**, with no improvement in gait[31] **(C)**. It was also not considered better than conventional therapy[30] **(B)**, but as possible to associate with it and/or be indicated as an activity to be performed at home, at school or in the community, aiming functional improvement and minimization of secondary complications[30] (**B**).

10. Does the use of FES (Functional Electrical Stimulation) combined with LLLL muscular strengthening program promote gain in selective muscular control, thus favouring improvement in gait in children with CP?

In children with Cerebral Palsy of the type spastic diparesia and hemiplegic who deambulate, aged between five and fourteen years, submitted to treatment with FES of the type: stimulator with rectangular biphasic waveform, in the most affected lower limb gluteus maximus muscle, either in ventral decubitus, kneeing, sitting, or standing, for one hour a day, six days a week, during an eight-week period, with the following parameters set each week:

- 1st week: Fr = 10 Hz; Pulse = 75µs; On/Off = 5:10s; Ramp = 0.8s; Duration = 60min;
- 2nd week (segment 1): Fr = 30 Hz; Pulse = 100 µs; On/Off = 5:15s; Ramp = 0.8s; Duration = 30min;
- 2nd week (segment 2): Fr = 10 Hz; Pulse = 75 µs; On/Off = 5:10s; Ramp = 0.8s; Duration = 30min;
- 3rd-8th weeks: Fr = 30 Hz; Pulse = 100 µs; On/Off = 5:15s; Ramp = 0.8s; Duration = 60min;

Combined with conventional therapy and home applications, with weekly visits to monitor treatment progress, presented regular results, showing that regarding muscular strength (MS), only five of the children were capable of exerting force against resistance with the hip in a neutral position for both legs, showing that in the experimental group there was some improvement in MS, but not significant or superior compared to the control group. Regarding gait, the children who received stimulation presented little improvement in MS in hip extension, leading to increase in AOM, however, still small, which was not observed in the control group. Regarding passive amplitude of movement, average internal rotation limit slightly decreased, and the average external rotation limit discreetly increased in both groups. Regarding gross motor function, there was increase in section E score, walking, running and jumping, for both groups. This increase was slightly higher in the stimulation group, but there was no significant difference between both groups[32] **(B)**.

In children with CP of the type hemiparesia and diparesia, aged between four and fifteen years, who during gait in the initial contact performed forefoot support and knee flexion due to weakness of dorsiflexors and quadriceps, respectively, in gait initial contact and orthostatism, it was used stimulating FES in these muscles. The placement of the proximal electrode was over the motor point of the anterior tibial muscle and the distal electrode was placed over the extensors of the toes, and for the quadriceps muscle, the proximal electrode was placed over the anterolateral side of the thigh and the distal electrode was placed over the motor point of the medial vastus muscle, with the following parameters: Amplitude/Intensity - 20 to 70 mA; - Frequency: 40 Hz; - Time of ascent, descent and maintenance: adjusted for each individual; Pulse width: ranging between 3-350 µs. Duration was eigth weeks, being used at home and school, with weekly visits from physical therapists to monitor and adjust electrode placements. Before the eight-week functional application, an adaptation period of two weeks, being one hour a day within six days using neuromuscular electrical stimulation to acquaint the child with the electrical stimulation that would be provided by FES, and to improve the strength of the muscles in question. In the adaptation phase the following parameters were used: 1st week: Frequency: 40 Hz (work cycle: 6 seconds *on* and 14 seconds *off*) in 30 min, followed by thirty minutes at 10 Hz (work cycle: 6 seconds *on* and 10 seconds *off*) to avoid muscular fatigue, and on the 2nd week, the composed stimulus was 60 minutes at 40 Hz (work cycle: 6 seconds *on* and 14 seconds *off*). Pulse duration was 100 µs for dorsiflexors and 150 µs for quadriceps. 100 µs were considered enough to provoke adequate contraction of dorsiflexors, with less discomfort in these children's small muscles. On the quadriceps a longer pulse duration was required to provoke a contraction. For the thirty minutes in the first week, were used 75 µs for both muscles to reduce the level of contraction, thus avoiding fatigue, maintaining a low level of stimulus to continue the acquaintance process. During the two weeks of adaptation, the parents gradually increased the intensity of stimulation, under guidance of the physical therapist until an effective, functional, and visible contraction of the target muscles was reached, without exceeding the limits of sensory tolerance. In this phase the motor points were defined for the placement of electrodes and, thus, established the use of FES. The electrodes were placed until a maximum contraction of the selected muscles was reached, with minimum discomfort, avoiding other muscle groups or any undesired limb movement. An electrical pulse generator - *"footswitch"*, was used inside the child's shoe, to activate the dorsiflexors as soon as the foot left the ground, at the time of gait. The definitions were adjusted for each child so that the dorsiflexors remained stimulated during the swing phase and support in a manner to prevent the foot from stomping when entering this phase. The quadriceps muscle was activated in initial contact and in load response. If needed, a lasting stimulation would be made in the intermediate support to maintain knee extension, being careful not to delay the start of knee flexion to initiate impulse phase. It was also tried to activate the quadriceps in the deceleration phase, but it was impossible due to the short swing phase in this type of children. The use of FES applied to dorsiflexors and quadriceps showed to be beneficial in children with CP, resulting in significant improvements when used every day for eight weeks, with adequate support from physical therapist and parents, leading to a systematic improvement in gait. Ten children who received FES in the dorsiflexors significantly improved AOM in the initial contact, in the swing phase, and in gait speed. Four children received FES in the quadriceps and showed decrease in knee flexion during the support phase. No significant differences were found regarding improvement between the experimental and control groups. The use of FES for the dorsiflexors resulted in one statistically significant effect at the peak of swing phase and initial contact, providing individual improvements of up to 8.8° for both phases during gait. Individual improvements, resulted from using FES on the quadriceps, ranged from 4.6° to 8.6°, therefore, with superior results to those found for dorsiflexors. The treatment group showed a tendency for improvement in the passive amplitude of movement of dorsiflexion compared to the control group (7.2° vs 0.4°)[33] **(B)**.

Recommendation

The application of functional electrical stimulation combined with conventional therapy and home applications, in children with CP of the type diparesia and hemiparesia, aged between four to fifteen years, with an eight-week program, during one hour a day, six days a week, using the stimulator, with symmetrical biphasic waveform, on the gluteus maximus muscle, quadriceps, and dorsiflexors, with the following parameters: Frequency: 10 - 40 Hz; Pulse width: 3-350 µs; *On*/*off* and ramp: variating for each individual, intensity: for functional phase the intensity must reach a visible contraction of the muscle within its sensory solerance; Duration: thirty to sixty minutes, is beneficial to improve selective muscular control and gait, being more effective in the quadriceps and dorsiflexor muscles than in the gluteus maximus muscle[32] **(B)**.

11. Is the use of body-weight support on the treadmill effective for gait training in children with cerebral palsy?

For children with CP of the type spastic diplegia, spastic tetraplegia and ataxic spastic tetraplegia, with treatment program on the treadmill with partial body-weight support during three months, with six thirty-minute sessions a week combined with a conventional physical therapy treatment, once a week in use of drugs, show significant improvements in gross motor function (*Gross Motor Function Measure*) in orthostatism in addition to gait independency level (*Functional Ambulation Category*)[34] **(B)**.

By comparing the same treatment in children with CP of the type athetoid quadriplegia, spastic quadriplegia and diplegia, for six weeks, performed over a period of two times a week, during thirty minutes, with one day of rest between sessions, comparing with who performed only conventional physical therapy, it is observed that the use of partial body-weight support has greater benefit in the ten meter per minute test assessment with absolute risk reduction of 80% (CI 95% - 21% to 100%), and benefits one out of two patients treated (NNT = 2, CI 95% 1 to 7). It shows improvement in the children's resistance as well as gait independency level (*Functional Ambulation Category*)[35] **(B)**.

In children with CP, in a twelve-week treatment, during twenty minutes, two to three times a week, combined with conventional treatment for a period of two to three times a week during thirty minutes per session, when compared to the group of children who performed only conventional physical therapy, it was showed to be beneficial in the increase of step length ($p < 0.05$), in the decrease in double-support time ($p < 0.05$), and in the average of gross motor function ($p < 0.05$); no improvement was observed for the parameters of gait velocity and cadence[36] **(B)**.

The children with CP classified with difficulty level from moderate to severe, GMFCS levels III and IV, follow the training protocol for the period of nine weeks, with two sessions a week, during thirty minutes. The study shows that there is no significant improvement in the assessed resistance and speed between partial body-weight-supported gait training on the treadmill and overground gait training in external environment[37] **(B)**.

Recommendation

The use of body-weight-support for gait training in children with cerebral palsy is clinically recommended to improve their gait motor skills. Children with CP of the type spastic diplegia, spastic tetraplegia, and ataxic spastic tetraplegia show improvement in gross motor function and gait, in addition to gait independency level[34] **(B)**.

Children with CP of the type athetoid quadriplegia, spastic quadriplegia and diplegia show improvement in resistance and gait independency level (*Functional Ambulation Category*)[35]**(B).** There is no difference between partial body-weight-supported gait training on the treadmill and overground gait training in external environment regarding resistance, gait speed and cadence[36, 37]**(B)**.

12. Are there benefits in the use of virtual reality to improve lower limb function in children with cerebral palsy?

CP refers to an incapacity for controlling and coordinating voluntary and selective movement of the muscles, leading to the alteration of biomechanical functions in these children.

Virtual reality may propitiate and motivate children to practice the exercises to improve their performance and desired function.

A study containing ten CP children, four boys and six girls, eight children of the type hemiplegia and two of the type diplegia, were classified by the *Gross Motor Functional Classification Sistem* (GMFCS) at levels one and two, indicating independent gait with or without auxilliary devices, and six children without cerebral palsy, two boys and four girls. The children were aged seven to seventeen years and all were submitted to exercises with virtual reality (VR), and conventional exercises for the selective movement of dorsiflexion of the ankles. All the children clearly showed themselves to be interested in the treatment with virtual reality. Conventional treatment obtained significantly the higher number of repetitions ($p < 0.04$), and of time ($p < 0.01$) to perform the movement of dorsiflexion of the ankle. The treatment with virtual reality (VR), compared to the conservative treatment, the participants with and without CP obtained significant variations in the active movement of the ankle at the time of dorsiflexion.

The results of treatment using virtual reality compared to conventional exercises it showed that the children without CP ($p < 0.03$) and with CP ($p = 0.09$) were benefitted[38] **(B)**.

Recommendation

The treatment with virtual reality exercises VR showed to be effective in the motivation and motor selectivity in children both with and without cerebral palsy. There is need of more evidence by means of controlled and randomized studies with this type of population.

13. Is the use of robotic device for treadmill gait training effective for children with cerebral palsy?

One study tested the use of robot-assisted therapy on the treadmill in children with cerebral palsy of the type spastic diplegia. Two groups were compared with different classifications of independence and functionality, GMFCS levels I and II, and GMFCS levels III and IV, it is observed that there is improvement in both groups, GMFCS levels I and II obtained better and significant results for gross motor function in walking, running, jumping and orthostatism, training for three weeks, four sessions a week, with average duration of thirty-eight minutes[39] **(C)**.

On children with cerebral palsy, GMFCS level III, it showed to be effective in improving speed, resistance, and gross motor function, GMFM, of gait and orthostatism on the ground after the child was submitted to a three-week program, four sessions a week, with average duration of thirty-four minutes, with body-weight support of 50%[40] **(C)**.

On children with CP of the type spastic diplegia and tetraplegia, the two-week training, during thirty minutes, all days of the week, analyzes robot-assisted treadmill gait training. In this analysis there was significant improvement in the increase of speed ($p = 0.001$) and in the step length ($p = 0.010$). The events that assess the children's resistance, the 10 meters/minute walking test, absolute risk reduction in 83% (CI 95% 28 to 100%) and benefits one out of two patients treated (NNT = 2, CI 95% 1 to 5). On the six-minute walk test absolute risk reduction in 100% and benefits two out of four patients treated (NNT = 2, CI 95% 1 to 4)[41] **(B)**.

Recommendation

The studies that evaluate the use of robotic device to improve gait in children with cerebral palsy show the validity of the resource. However, it must be considered that it is a new resource and that it requires further randomized and controlled studies, in addition to the matter having been studied in small populations.

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