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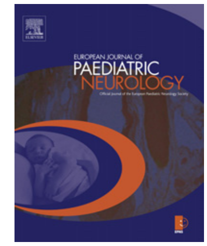

Original article

The effect of different physiotherapy interventions in post-BTX-A treatment of children with cerebral palsy

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ABSTRACT

Aim: To distinguish the effects of different physiotherapeutic programs in a post BTX-A regime for children with Cerebral Palsy (CP).

Design: Retrospective, controlled intervention study.

Participants and interventions: A group of 38 children ($\overline{X}$ = 7y7m, GMFCS I-III, 27 bilateral, 11 unilateral CP) receiving an individually defined Neurodevelopment Treatment (NDT) program, was matched and compared to a group of children with the same age, GMFCS and diagnosis, receiving more conventional physiotherapy treatment. All patients received selective tone-reduction by means of multilevel BTX-A injections and adequate follow-up treatment, including physiotherapy.

Outcome measures: Three-dimensional gait analyses and clinical examination was performed pre and two months post-injection. Treatment success was defined using the Goal Attainment Scale (GAS).

Results: Both groups' mean converted GAS scores were above 50. The average converted GAS score was higher in the group of children receiving NDT than in the group receiving conventional physiotherapy ($p < 0.05$). In the NDT group, overall treatment success was achieved in 76% of the goals, compared to 67% of the goals defined for the conventional physiotherapy group. Especially for the goals based on gait analyses ($p < 0.05$) and in the group of children with bilateral CP ($p < 0.05$), treatment success was higher in the NDT group.

Conclusion: In a post-BTX-A regime, the short-term effects of an NDT approach are more pronouncedthan these from a conventional physiotherapy approach.

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1. Introduction

Cerebral palsy (CP) applies to an insult of the developing brain that produces a disorder of movement and posture. Whilst the brain defect or lesion is permanent and non-progressive, the resultant is not unchanging.[1–3] Primary symptoms of cerebral palsy are problems with muscle tone, balance, selectivity and strength. These problems as well as secondary symptoms including fixed muscle contractures and bony deformities, can lead to abnormal motion patterns and coping responses.

In treatment of CP, the use of Botulinum Toxin A (BTX-A) is commonly accepted as a selective tool to reduce spasticity. This neurotoxin, injected intramuscularly, is taken up at the cholinergic nerve terminal, where it blocks the release of acetylcholine, causing selective, temporary muscle denervation. When BTX-A is injected, correct patient selection, age, treatment dose and accurate muscle selection are crucial.[4–6] An adequate follow-up treatment including orthotic management, serial casting and intensive physiotherapy are of major importance for a maximal profit of the BTX-A injections.[7–12] The selective chemodenervation of overactive muscles, induced by the use of BTX-A, creates basic conditions that are necessary to improve muscle length, enhancing the potential to strengthen the antagonist muscles. This period of reduced muscle tone is crucial. It allows children with CP to learn new patterns of movement on which to build functional abilities and optimize their motor development[13,14] and thereby facilitates the physical therapy program.[15]

In physiotherapy treatment of CP children, varying approaches and techniques are used, ranging from very conservative and conventional techniques like muscle strengthening, manual stretching, massage etc, to more complex motor learning based theories like neurodevelopment treatment (NDT), Vojta, Petö and several others. One of the most commonly used strategies in CP is neurodevelopment treatment. NDT is an interdisciplinary problem solving approach to the assessment, treatment and management of individuals with changes in sensorimotor, perceptual and cognitive function, tone and patterns of movement resulting from a central nervous system lesion.[16,17] In treatment of CP, effects of NDT are reported mainly on functional measures, using the Gross Motor Function Measure (GMFM), Pediatric Evaluation of Disability Inventory (PEDI) and others.[18–21]

The influence of physiotherapy is not easy to evaluate and studies on the effectiveness of different physiotherapy programs report conflicting and inconsistent findings.[22] Researchers face inevitable methodological problems and practical constraints, such as small and heterogeneous samples, non-random assignment into groups, lack of a control non-treatment group and inappropriate outcome measures.

Increased muscle tone complicates the optimal set-up of a physiotherapy program and may therefore be one of the causes of a lack of response. The post-BTX-A situation can therefore be seen as an optimal condition to evaluate differences between different physiotherapy approaches, as the reduced tone facilitates the exercises for motor learning. Only few studies investigated this combined effect of a BTX-A treatment program with an intensive physiotherapy program.[10,23,24] Outcome measures seem to be very variable and no consensus is found on which specific exercises and techniques are indicated to optimize the effect of tone-reduction.[25]

The purpose of this study was to distinguish the effects of different physiotherapeutic interventions on gait and clinical parameters of 76 children with CP in a post BTX-A regime, evaluated by means of the Goal Attainment Scale (GAS). A neurodevelopment treatment approach was compared with more conventional physiotherapy treatment techniques.

2. Method

2.1. *Patients*

Patient selection was done retrospectively out of a group of children with CP who received BTX-A treatment at the ***blinded*** hospital. Inclusion criteria were diagnosis of CP, age between 4 and 18 years and gait analyses before and two months after the injection. A group of 38 patients receiving frequent NDT was randomly selected and matched with a control group of the same size receiving conventional physiotherapy. Matching was based on age, diagnosis and level on the Gross Motor Function Classification System (GMFCS) (Table 1). The first group received multilevel BTX-A followed by NDT by a qualified physiotherapist with a specific training in NDT. This group had a mean age of 7y7m at the time of BTX-A. The second group received multilevel BTX-A injections followed by conventional physiotherapy techniques (muscle strengthening, stretching etc). Their physiotherapy treatment was performed by a qualified, traditionally schooled physiotherapist who never followed an additional training in NDT nor in specific treatment strategies for post-BTX-A treatment. Mean age at moment of BTX-A injection of this group was 7y5m. In general, the NDT approach is considered as being focussed on promoting motor development and function while conventional physiotherapy is known to have more isolated focuses like on muscle length, muscle strength etc.

All patients received multilevel BTX-A infiltration in 2–5 muscles per limb. The most frequently injected muscles were m.Gastrocnemius, m.Psoas and the Hamstrings muscles. Other target muscles were m.Soleus, Adductors, m.Tibialis Posterior and m.Rectus Femoris (Table 2). Muscle selection was similar for both treatment groups. Target muscles and treatment dose were defined individually on the basis of objective measurements of pathological gait and clinical examination by the same multidisciplinary team (an orthopaedic surgeon, a neuropaediatrician, a rehabilitation physician, a kinesiologist and a physiotherapist). All muscles were injected at multiple sites in order not to exceed the maximum dose of 50 units of BTX-A per location and a dilution of 100U of BTX-A in 2 ml Saline (Allergan, IC, Irvine, CA USA) was used. Injection was performed under general mask anaesthesia.

2.2. *Study design*

Current status in motor development was determined before and two months after the BTX-A injections. All children were evaluated by means of three-dimensional gait analyses,

Table 1 – Patient characteristics and aftercare.

	BTX-A + NDT	BTX-A + conventional physiotherapy
N	38	38
Gender		
Male	18 (47%)	22 (58%)
Female	20 (53%)	16 (42%)
Diagnosis		
Bilateral CP	27 (71%)	27 (71%)
Unilateral CP	11 (29%)	11 (29%)
Age at BTX-A (mean + range)	7y7m (3y1m - 15y5m)	7y5m (2y9m-14y7m)
GMFCS		
GMFCS I	14 (37%)	14 (37%)
GMFCS II	14 (37%)	14 (37%)
GMFCS III	10 (26%)	10 (26%)
Post BTX-A evaluation	2m11d (1m21d - 3m19d)	2m14d (30d - 4m6d)
BTX-A history	21 (55%)	23 (61%)
Orthopaedic surgery history		
Soft tissue release	0 (0%)	1 (3%)
Bony corrections	0 (0%)	2 (5%)
Combination	2 (5%)	1 (3%)
Use of day orthosis pre BTX-A		
No	9 (24%)	13 (34%)
< 50%/day	6 (16%)	6 (16%)
> 50%	23 (61%)	19 (53%)
Use of day orthosis post-BTX-A		
No	1 (3%)	4 (10%)
< 50%/day	4 (11%)	6 (16%)
> 50%	33 (87%)	28 (74%)
Use of night orthosis pre BTX-A		
No	22 (58%)	24 (58%)
< 50%/day	7 (18%)	8 (21%)
> 50%	9 (24%)	8 (21%)
Use of night orthosis post-BTX-A		
No	4 (11%)	5 (13%)
< 50%/day	13 (34%)	14 (37%)
> 50%	21 (55%)	19 (50%)
Physiotherapy preBTX (Mean + SD)	3,2 sessions/ week (SD 1.3) 45 min/ session (SD 15.6)	3.2 sessions/ week (SD 1.6) 36 min/ session (SD 14.7)
Physiotherapy postBTX (Mean + SD)	3.8 sessions/ week (SD 1.1) 47.7 min/ session (SD 13.9)	3.9 sessions/ week (SD 1.5) 39.5 min/ session (SD 17.3)
Duration of casting	16.1 days (SD 9.0)	13.2 days (SD 10,3 days)

including kinematics, kinetics, surface electromyogram (EMG) and additional video-registration with five digital cameras. An additional clinical examination was used to evaluate of joint range of motion and bony deformities, spasticity, muscle strength and selectivity.

2.3. Outcome measures

Treatment success was defined using the Goal Attainment Scale (GAS). GAS is an individualized, criterion-referenced measure that quantifies the achievement of intervention goals for different kinds of treatment issues.[26]Children with CP represent a very heterogeneous group, each child demonstrating various problems at different levels. Using GAS enhances tracking individual progress and reduces the phenomenon of ‘regression to the mean’. For this study, the original version of the GAS was used, as defined by Kirusek et al.[26] and used in several pediatric rehabilitation studies.[27–29] At the *** hospital, as part of routine clinical practice, individual goals for BTX-A treatment are stipulated by the multidisciplinary team, prior to the BTX-A treatment, based on the evaluation data including kinematics, kinetics and EMG of gait evaluation and/or observational analysis. In this study, an independent assessor, who was never involved in the treatment of the subjects nor in the evaluation procedure, and who was blind for the group allocation, retrospectively translated the prospective treatment goals into 3 to 6 specific, individual goals, each defined by a specific gait or clinical parameter and formulated according to the SMART principle (specific, measurable, acceptable, realistic and time-based).[30] The specific goals were selected out of an available list of 245 clinically relevant specific goals for BTX-A treatment based on gait, clinical examination and other parameters (such as hygiene, pain or measures on X-rays). This list of goals was developed by the multidisciplinary team prior to the study. The selected specific individual goals were defined retrospectively, and thus not shared with the physiotherapist.

The achievement of the specific goals was subsequently assessed by the comparison of these parameters on the pre- and post evaluations. An ordinal scale between −2 and 2 was used to rate each goal. The expected level of success was given score 0 when at least 30% of the pre-treatment gait pathology was corrected. The amount of pre-treatment pathology was defined by comparing the pathological pattern with the typical mean, taking into account the typical standard deviation (standardised score calculated with mean and standard deviation of a group of typically developing children). For the calculation of the typical means, data of a group of 65 age related typically developing children was used as a reference. When the correction was more than 30%, a score of +1 was given. The most favourable outcome was a score of +2, when more than 50% of the pathology was corrected. Less than expected results (unchanged situation, defined by <30% of change) and the least favourable outcomes (increased pathology defined by >30% of the pre-treatment pathology) were scored −1 and −2 respectively. The scores of all individual goals were summed and converted into a standard T-score with an equal weight for each goal. Converted GAS scores under 50.0 were considered as non-successful treatments. Scores of 50.0 or more represented successful treatments. In an independent reliability study on 30 children with CP, excellent GAS intra- and interrater reliability was obtained for the converted total GAS score estimated according to the above described principles (Intraclass Correlation Coefficient (ICC) = 0.988 and Standard Error of

Table 2 – Target muscles.

	N (legs)	
	NDT	CONV
m.Psoas – Hamstrings – m.Gastrocnemius	22	26
m.Psoas – Hamstrings – m.Gastrocnemius – m.Soleus	1	0
m.Psoas – Hamstrings - Adductors – m.Gastrocnemius	8	15
m.Psoas – Hamstrings - Adductors – m.Gastrocnemius – m.Soleus	4	0
m.Psoas – Hamstrings – m.Gastrocnemius – m.Soleus - m.Tibialis Posterior	0	1
m.Psoas – Hamstrings – Adductors	5	5
m.Psoas – Hamstrings	10	7
Hamstrings	1	0
Hamstrings – m.Gastrocnemius	6	4
Hamstrings – Adductors – m.Gastrocnemius	2	0
Hamstrings – m.Gastrocnemius – m.Soleus	1	2
Hamstrings – Adductors – m.Gastrocnemius – m.Soleus	0	1
Hamstrings – m.Gastrocnemius - m.Soleus – m.Tibialis Posterior	1	1
Hamstrings – m.Gastrocnemius – m.Tibialis Posterior	2	2
Hamstrings – Adductors – m.Gastrocnemius – m.Tibialis Posterior	1	0
Hamstrings - Adductors - m.Gastrocnemius - m.Tibialis Posterior	1	0
Gastrocnemius	0	1

Measurement (SEM) = 0.964 for intrarater reliability; Intraclass Correlation Coefficient (ICC) = 0.945 and Standard Error of Measurement (SEM) = 1.992 for interrater reliability).

All therapists following children included in the study received a standardized written questionnaire on the contents and frequency of therapy sessions. This questionnaire was part of the routine follow-up protocol for all CP children evaluated at ***blinded*** hospital. Information from this explorative questionnaire was thereby derived retrospectively and aimed at giving general descriptive information on both therapy approaches. A copy of the questionnaire was provided in appendices.

2.4. Statistical analyses

Between-group differences in baseline conditions were evaluated using a paired samples *t* test (physiotherapy duration and frequency, number of casting days) and a Wilcoxon Signed Rank test (use of orthosis). To quantify the impact of the number of casting days on the total GAS score, an Analysis of Variance (ANOVA) test was used. The frequency distribution of the selection of muscles (Table 2) was tested using a Pearson chi-square test.

As the distribution of the converted GAS scores was tested as normal, differences in converted GAS scores between both groups were analyzed using a paired samples *t*-test. Statistical difference in frequency distribution of GAS subscores was determined by a Pearson Chi square test.

A schematic overview of the data-analyses is given in Fig. 1.

Within each group, time and distance parameters pre-and post-injection were compared using a paired samples *t*-test, quantifying the effect of both therapy programs. Additionally, the effects on time and distance parameters were mutually compared using a paired samples *t*-test on difference scores between the pre-and post-condition. The results of the

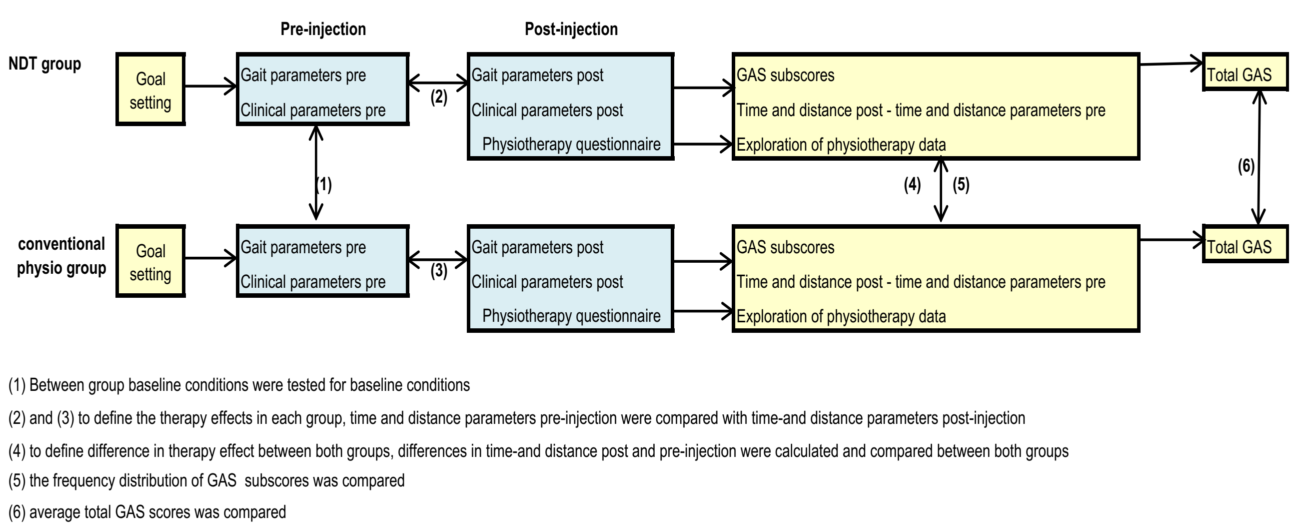

Fig. 1 – Schedule of data-collection and analysis.

physiotherapy questionnaire were mainly analyzed descriptively, with inclusion of a Pearson Chi square test to evaluate differences in frequency distributions.

For all statistical analyses, SPSS 15.0 for Windows was used.

3. Results

3.1. Patient and treatment characteristics

In each group, 27 children (71%) were diagnosed with spastic bilateral and 11 (29%) with unilateral CP. Fourteen patients (37%) functioned on GMFCS level I, 14 patients (37%) on level II and 10 patients on level III (26%). In the NDT group, 21 patients received one or more BTX-A infiltrations in the past and two patients had a history of orthopaedic surgery, whereas in the conventional physiotherapy group, 23 patients already received one or more BTX-A infiltrations and four patients underwent orthopaedic surgery in the past (Table 1). None of the children received orthopaedic surgery within 18 months before the BTX-A infiltration. Study of the number of previous BTX-A treatments for the included patients did not reveal differences between both groups (chi^2 $p = 0.777$). In the NDT group, seven children received their fourth BTX-A treatment or more, while in the control group ten children received their fourth BTX-A treatment or more.

The averaged number of target muscles was 5.5 in the NDT group and 5.4 in the group receiving conventional therapy (paired samples *t*-test: $p = 0.711$). Also the distribution of target muscles and level of injections (Table 2) did not reveal significant difference (Chi^2 $p = 0.158$) The total dosage of BTX-A was 19.0 units per kg body weight for the NDT group and 20.1 units per kg body weight for the conventional physiotherapy group (paired-samples *t*-test: $p = 0.411$).

Before the injections, 61% of the NDT group wore their day-orthosis more than 50% per day, in comparison to 50% for the group of children following conventional physiotherapy. This increased to 87 and 73% respectively post-BTX-A. An increased intensity of physiotherapy post BTX-A was mainly noticeable in the frequency of therapy sessions, increasing from 3.2 sessions pre-BTX-A to 3.8 sessions per week post-BTX-A in the NDT group and from 3.2 to 3.9 sessions per week in the conventional physiotherapy group.

Except for four children of the NDT group (15%) and eight children of the conventional physiotherapy group (30%), all children received casting before or after the BTX-A injections. An average of 16.1 casting days post-BTX-A was noted for the NDT group and 13.2 days for the conventional physiotherapy group. The number of casting days, the orthotic management and frequency and duration of physiotherapy was comparable in both groups and no statistical differences were found.

3.2. Goal selection

A total of 734 goals were scored. Twenty percent of the goals were based on clinical examination, 77% were based on gait parameters and 3% were additional parameters (use of orthosis and walking aids and X-ray hip measures). The most popular goals on clinical examination were the Thomas test measuring hip extension (7%) and spasticity of m.Soleus (4%) and Hamstrings (4%) measured by a Tardieu score. Most frequently selected goals on gait parameters were knee angle at initial contact (14%), maximum hip extension in stance (11%) and ankle second rocker (10%) (Table 3).

3.3. GAS scores

The NDT group had a mean converted GAS score of 56, which is significantly higher than the average of 51 of the conventional physiotherapy group (paired samples *t*-test: $p = 0.008$). (Fig. 2).

Specifying according to typology of cerebral palsy, the children with bilateral CP showed a significantly higher converted GAS score in the NDT group than the children with bilateral CP from the conventional physiotherapy group (paired samples *t*-test: $p = 0.004$). This significance could not be found for the children with unilateral CP.

No significant influence of number of castings days was found on the converted GAS score (ANOVA: $p = 0.33$).

Taking into account the subscores in each group (Fig. 3), it could be recognized that for 76% of the goals set in the NDT group, treatment success was achieved, meaning a GAS score higher than 0. This was only valid for 67% of the goals set for the conventional physiotherapy group. For 24% of the goals set for the NDT group and 33% of the goals in the conventional physiotherapy group, a stabilized condition or increased pathology was measured (GAS -1 or -2).

Focussing on gait parameters, treatment success was achieved for 75% of the goals set for the NDT group, whereas for the conventional physiotherapy group, this was only achieved for 67% of the goals. For the goals derived from clinical examination, this percentage was 77 and 67% respectively.

The frequency distribution of subscores was tested by Chi-square and recognized a significant difference between both groups for all goals ($p = 0.007$) and for the goals derived from gait parameters ($p = 0.019$) but not for the goals derived from clinical examination ($p = 0.17$) (Table 3).

3.4. Time and distance parameters

Step width improved significantly in the group of children receiving NDT (paired samples *t*-test: $p = 0.041$), while none of the time-and distance parameters improved significantly in the group of children receiving conventional physiotherapy. However, no significant differences between both groups were found when comparing the effect of therapy on time-and distance parameters.

3.5. Questionnaires

At time of BTX-A injection, the physiotherapists of the NDT group had an average of 16 years of experience and the conventional physiotherapists had an average of 17 years experience. In both groups, more than 50% of the therapists had more than 15 years experience. No statistically significant difference was found in the experience level of the physiotherapists.

Table 3 – Frequency distribution of the GAS subscores for the selected goals.

	NDT group						Conventional PT group						Tot	Tot %	p (chi^2)
	−2	−1	0	1	2		−2	−1	0	1	2				
Clinical examination															
Hip extension deficit (Thomas test)	1	7	3	6	0	17	2	8	6	17	0	33	50	7%	
Spasticity of m.Soleus (Tardieu)	0	1	6	7	2	16	0	5	6	5	0	16	32	4%	
Spasticity of hamstrings (Tardieu)	0	0	3	4	0	7	0	8	11	4	0	23	30	4%	
Popliteal angle	0	2	0	5	0	7	0	1	1	2	0	4	11	1%	
Knee extension deficit	0	2	1	1	0	4	2	0	0	0	0	2	6	1%	
Others	0	2	5	4	1	12	0	1	2	0	0	3	15	2%	
Total	1	14	18	27	3	63	4	23	26	28	0	81	144	19.6%	0.177
Total %	2%	22%	29%	43%	5%	100%	5%	28%	32%	35%	0%	100%			
Gait															
Knee angle at IC	2	20	11	13	7	53	3	22	16	6	2	49	102	14%	
Maximum hip extension in stance	2	15	9	13	2	41	1	18	12	9	1	41	82	11%	
Maximum knee extension in stance	0	8	9	14	4	35	1	20	8	10	2	41	76	10%	
Ankle 2nd rocker	0	4	11	12	8	35	0	7	16	14	1	38	73	10%	
Ankle ROM during push-off	0	3	9	6	0	18	0	8	8	10	0	26	44	6%	
Ankle dorsiflexion in swing	0	1	5	10	7	23	0	2	5	7	5	19	42	6%	
Ankle angle at IC	0	3	3	7	3	16	0	4	1	11	6	22	38	5%	
Maximum knee flexion in swing	0	2	1	4	3	10	1	2	0	5	0	8	18	2%	
Maximum dorsiflexion in stance	0	0	5	2	1	8	0	0	0	1	1	2	10	1%	
Others	0	12	10	20	3	45	1	5	18	13	1	38	83	0.113	
Total	4	68	73	101	38	284	7	88	84	86	19	284	568	77.4%	0.020
Total %	1%	24%	26%	36%	13%	100%	2%	31%	30%	30%	7%	100%			
Additional parameters	0	6	2	5	0	13	0	2	2	5	0	9	22	3%	0.141
Total %	0%	46%	15%	38%	0%	100%	0%	9%	9%	23%	0%	100.0%			
Total	5	88	93	133	41	360	11	113	112	119	19	374	734	100%	0.007
Total %	1%	24%	26%	37%	11%	3%	30%	30%	32%	5%					

From 23 children (61%) following NDT treatment and 17 children (44%) following conventional physiotherapy, information regarding therapy contents and methods was available.

Seventy nine percent of the NDT therapists and 65% of the traditionally schooled physiotherapists frequently used passive stretching in their therapy. Ninety-six percent of the NDT therapists frequently used active stretching methods, compared to 88% percent of the traditionally schooled physiotherapists.

Inhibition techniques were frequently used by 67% of the NDT therapists and 41% of the traditionally schooled therapists, but three NDT therapists and four conventional physiotherapists never used these techniques. All except one conventional physiotherapist frequently used functional training in their treatment. One traditionally physiotherapist never used muscle strengthening. Testing difference in frequency distribution between both groups using chi-square testing showed no statistical significance.

Fig. 4 compares the average time per therapy session spent on tone reduction, mobilization, tonification, functional training and others in each group. For the NDT group, the average time per therapy spent on functional training was 42% per session. In the group of conventional physiotherapists, this was only 28% per session which was significantly less (0.009). The traditionally schooled therapists spent more

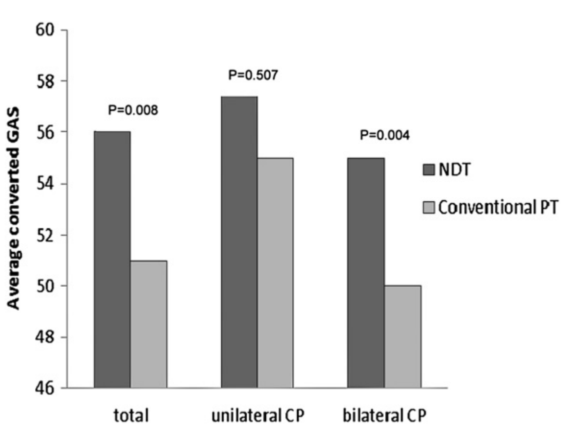

Fig. 2 – Average converted GAS.

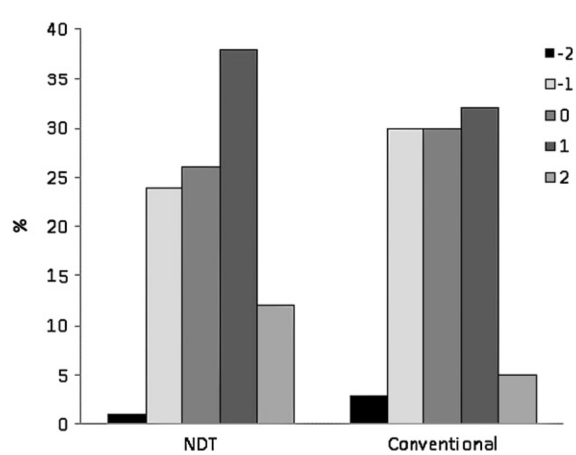

Fig. 3 – GAS - Frequency of subscores per group.

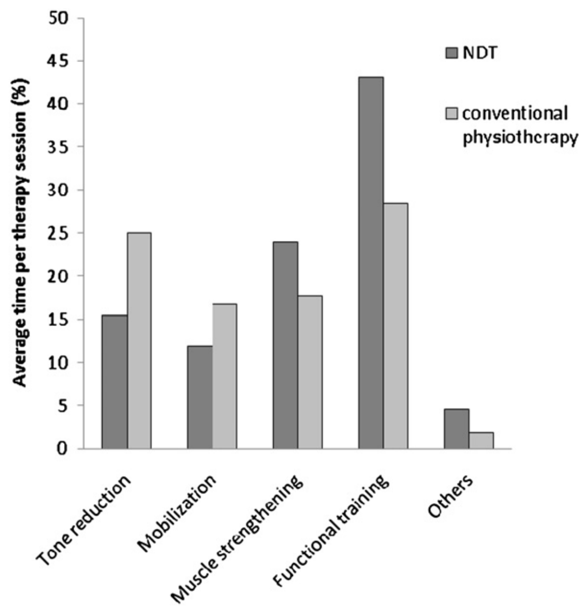

Fig. 4 – Average time per therapy session.

time per session on tone-reduction and mobilization, but this difference was not statistically significant.

4. Discussion

This study aimed to distinguish the effects of different physiotherapeutic interventions in a post BTX-A treatment regime on gait pattern and clinical parameters of children with cerebral palsy.

Converted GAS scores of both groups demonstrated an overall positive evolution in both groups. So in general, all children benefited from an integrated BTX-A treatment including orthotic management, casting and intensive physiotherapy. These results support the importance of an intensive physiotherapy program during the period of tone reduction. A recent study[31] indicated age, level of treatment and casting as the most crucial factors influencing treatment success in BTX-A treatment of children with CP. Detailed analysis of baseline characteristics and BTX-A treatment details (Tables 1 and 2) revealed that, apart from the physiotherapy regime, the treatment strategy was similar for both age-matched groups. The averaged treatment interval of integrated multilevel BTX-A treatment applied in this study was approximately one year. Previous research[32] also highlighted that treatment intervals of approximately one year remained stable within 4, 5 and 6 subsequent BTX-A treatments. Long-term multi-level BTX-A applications could therefore be considered a safe and stable treatment option for children with cerebral palsy and the formation of antibodies was thereby indirectly precluded.[32] More-over, study of the number of previous BTX-A treatments for the included patients of the current study did not reveal differences between both groups.

A significant higher success ratio was recognized for the children receiving NDT and more children profited from this approach compared to the conventional approach. Despite a slightly lower frequency in physiotherapy post BTX-A in the NDT group, this group had a significantly higher converted GAS score and a larger number of treatment goals were achieved.

Mainly the treatment goals based on gait parameters, showed a significantly different distribution of outcome scores for both groups. The average percentage of therapy spent on functional training and tonification was larger in the NDT group, which may be one of the various explanations for these differences. More NDT therapists reported the frequent use of active and passive stretching techniques but the average time per session used for mobilization was longer in the group of traditionally schooled physiotherapists. However, surprisingly, in general the differences between both physiotherapy programs were rather limited. For example, the NDT therapists spent less time on tone reduction and mobilisation than conventional physiotherapists, while these were often seen as the core skills in the original Bobath approach. These findings agree with the statements of Butler and Darrah[21] highlighting that the NDT or Bobath approach is continuously evolving. The Bobath approach currently acknowledges the essential role of motor learning, orthotic management and strengthening exercises in physiotherapy of children with CP.[33] By specific preparation for specific function, the Bobath approach means not only to influence tone and facilitate movement, but also tries to translate more efficient patterns of activity obtained by handling into the practice of the required skills and believes that simple practicing movement patterns will not teach a child to perform skills not previously experienced.

The average duration of casting was higher in the NDT group than in the group receiving conventional physiotherapy, which may have improved the results in this group.[9] However, in this study, no significant influence was found when testing this difference. The differences in number of castings days were also not reflected in the individual GAS scores of the goals based on ROM parameters.

General information regarding therapy contents and used methods was available for 62% of the children (47 children). Therefore, to make assumptions regarding the entire group, these descriptive results should be interpreted cautiously. Unfortunately, the questionnaire (which was standard part of the gait analysis report) did not include detailed descriptions of the different exercise categories. It should be taken into account that the content and the specific goals of the listed exercise categories may therefore vary between therapists.

In this study, the average converted GAS score was higher in the group of children with unilateral CP and this in both intervention groups, indicating that therapy effects were higher in children with unilateral CP than in children with bilateral CP. This difference in therapy effects can be related to the spontaneous evolution of children with unilateral CP, who function on a higher GMFCS level. In general, children with GMFCS level I or II are known to show a more positive motor evolution than more involved children.[31–33] Controversially, difference in therapy response between conventional physiotherapy and NDT was significant in the group of children with bilateral CP but not in the group of children with unilateral CP, demonstrating that the higher functional level of the children with unilateral CP makes these children less sensitive to differences in therapy approaches.

In literature, very limited information is available on the specific effect of a physiotherapy program post BTX-A with insufficient evidence to either support or refute the use of these specific therapy interventions. An AACPDM evidence report on the effectiveness of therapy for children with cerebral palsy found only one randomized controlled trial with results demonstrating that electrostimulation post injection does not enhance the effect of BTX-A on gait.[25]

In two multicentre, randomized trials, Scholtes et al[10,23] reported significant different treatment effects when comparing an intervention group (multilevel BTX-A + physiotherapy) with a control group that only received usual physiotherapy. The intervention group showed significant better knee extension parameters at 6 weeks post-intervention. Improved muscle length of the hamstrings muscles and m.Gastrocnemius and GMFM-66 scores were reported up to 24 weeks post-intervention.

Only children with a flexed knee gait pattern were selected. Additionally, comparing an intervention outcome starting from different baseline conditions (BTX-A versus non-BTX-A) makes interpretation of the results and comparison with the present study difficult. Still, this study supports the importance of an integrated post BTX-A approach and demonstrates the importance of an intensive physiotherapy program post BTX-A. Leach[15] listed the elements of physiotherapy treatment following injection and emphasized the opportunities for physical therapy given by a period of tone-reduction. Not only does it facilitate joint and soft-tissue mobilization, it also represents a major opportunity for training appropriate functional skills.

Although further research is needed on the contents of different physiotherapy approaches, our study gives an indication that an NDT approach more frequently implements functional training than conventional physiotherapy and thereby attempts to benefit more optimally from the use of BTX-A.

In conclusion, this study shows an obvious trend demonstrating that an NDT approach is more effective than conventional physiotherapy techniques in the post-BTX-A treatment of cerebral palsy children. More research is needed to evaluate the difference on long-term effects.

Appendix. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejpn.2011.08.009.

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