Infants at very high risk of cerebral palsy

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DOES PHYSIOTHERAPEUTIC INTERVENTION AFFECT MOTOR OUTCOME IN HIGH-RISK INFANTS? AN APPROACH COMBINING A RANDOMIZED CONTROLLED TRIAL AND PROCESS EVALUATION

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ABSTRACT

Aim: The aim of this study was to examine the effects of intervention in infants at risk of developmental disorders on motor outcome, as measured by the Infant Motor Profile (IMP) and using the combined approach of a randomized controlled trial and process evaluation.

Method: At a corrected age of 3 months, 46 infants (20 males, 26 females) recruited from the neonatal intensive care unit at the University Medical Centre Groningen (median birthweight 1210g, range 585–4750g; median gestational age 30wks, range 25–40wks) were included on the basis of definitely abnormal general movements. Exclusion criteria were severe congenital disorders and insufficient understanding of the Dutch language. The infants were assigned to either the family centred COPing with and CAring for Infants with Special Needs (COPCA) intervention group (n=21; 9 males, 12 females) or the traditional infant physiotherapy (TIP) intervention group (n=25; 11 males, 14 females) for a period of 3 months. Three infants assigned to the TIP group (one male, two females) did not receive physiotherapy. IMP scores were measured by blinded assessors at 3, 4, 5, 6, and 18 months. At each age, the infants were neurologically examined. Physiotherapeutic sessions at 4 and 6 months were videotaped. Quantified physiotherapeutic actions were correlated with IMP scores at 6 and 18 months.

Results: The IMP scores of both the COPCA and TIP groups before, during, and after the intervention did not differ. Some physiotherapeutic actions were associated with IMP outcomes; the associations differed for infants who developed cerebral palsy (n=10) and those who did not (n=33).

Interpretation: At randomized controlled trial level, the scores of both the TIP and COPCA groups did not differ in effect on motor outcome, as measured with the IMP. The analysis of physiotherapeutic actions revealed associations between these actions and IMP outcomes. However, the small sample size of this study precludes pertinent conclusions.

What this paper adds

- This paper shows that the family-centred COPCA programme and TIP applied for 3 months in high-risk infants had a similar effect on motor outcome, as measured with the IMP.
- This study indicates that video analyses of physiotherapeutic sessions may assist in the understanding of working mechanisms of physiotherapy.

Infants at high risk for neurodevelopmental disorders are in need of early intervention, yet at the moment it is unknown which intervention is the most successful.[1–4] In addition, current interventions primarily promote cognitive development and have little[1,2] or no[3,4] effect on motor development. Therefore, a new family-centred intervention programme, COPing with and CAring for Infants with Special Needs (COPCA) was developed with the aim of promoting family function and motor and cognitive development (Dirks T and Hadders-Algra M, personal communication 2003). COPCA is a family relationship-orientated programme that is based on (1) a focus on the family including an educational component[5,6] and (2) a motor component, based on neuronal group selection theory (NGST).[7]

The keywords in NGST are primary and secondary variability, denoting two consecutive developmental phases. Typically, both phases are characterized by the presence of a variable motor repertoire. During the phase of secondary variability the child learns by means of trial and error to adapt the various motor strategies to the specifics of the situation. During primary variability movement adaptation is not possible – motor behaviour consists of exploration of the possibilities available.[8] An early lesion of the brain may result in a reduction of the motor repertoire and in deficits in the processing of sensory information.[9] Both factors may interfere with the selection of adaptive strategies for specific tasks. The reduction of the repertoire may be associated with the absence of the best strategy typically available for a situation; hence the child has to choose between alternative non-optimal strategies. Deficits in the processing of sensory information will interfere with the learning process of adaptation, which is based on the processing of feedback of self-produced trial-and-error achievements.

Recently, an early intervention project (the Dutch Vroegtijdig Interventie Project (VIP)) was carried out to evaluate the effects of COPCA in infants at risk for developmental disorders in comparison with traditional infant physiotherapy (TIP). In the Netherlands, TIP is mostly based on the principles of neurodevelopmental treatment.[10] The VIP project has been designed with a dual approach: a randomized controlled trial (RCT) and process evaluation. The latter approach was added as it was anticipated that heterogeneity in the application of physiotherapy[11] could result in a reduction of contrast between the two interventions. For the process evaluation, two intervention sessions per infant were video recorded. Next, the physiotherapeutic actions during the interventions were quantified with the help of a standardized protocol.[11]

The major goals of the COPCA programme are strengthening family participation and strengthening functional mobility. Functional mobility may be improved by influencing motor function at the impairment level, as defined by the International Classification of Functioning, Disability and Health for Children and Youth. As the motor domain of COPCA is based on the principles of NGST, the primary measure of the VIP project was motor outcome measured with the Infant Motor Profile (IMP), a recently developed instrument based on NGST.[12,13]

The present study aimed to unravel whether COPCA intervention and COPCA-related goals influence motor function at impairment level. To this end, we used the IMP to evaluate motor development of the 46 infants included in the VIP project. We were interested particularly in whether COPCA intervention resulted in an increased motor repertoire and a better capacity for adaptive selection. In line with the design of the study, first we evaluated the effects of the two interventions on IMP scores at RCT level and then we assessed the associations between physiotherapeutic actions and IMP scores.

METHOD

Participants

Of the participants of the VIP study admitted to the neonatal intensive care unit of the University Medical Centre Groningen between March 2003 and May 2005, 46 were included in the project at a corrected age of 3 months (20 males, 26 females; median gestational age 30wks, range 25–40wks; median birthweight 1210g, range 585–4750g) on the basis of presenting with definitely abnormal general movements at a corrected age of 10 weeks, indicating a high risk of developmental disorders.[14,15] Exclusion criteria were severe congenital disorders and caregivers' insufficient understanding of the Dutch language. The infants were randomly assigned into two groups, the COPCA group (n=21; 9 males, 12 females) and the TIP group (n=25; 11 males, 14 females). On paediatrician's advice, three infants in the TIP-group (one male, two females) did not receive physiotherapy. The flow chart of selection of infants included in the study is presented in Figure 1. The groups did not differ for most characteristics, except for maternal education, which was significantly higher in the TIP group (Table 1). The trial was approved by the medical ethics committee of the University Medical Centre Groningen.

Intervention

The intervention period was between 3 and 6 months corrected age. COPCA was provided twice a week in the home situation. The frequency and location of TIP intervention depended on the paediatrician's advice. Three comparison infants did not receive physiotherapy. After this intervention period, the paediatrician decided whether to continue intervention and which type of intervention to use for the infants in both groups. As a result, 36 infants received physiotherapy between the ages of 6 and 18 months. In the COPCA group, 15 infants continued with physiotherapy (12 with COPCA (mean number of sessions 6) and three with TIP as no COPCA coach was available (mean number of sessions 33)), four infants stopped receiving physiotherapy, and data were missing for two infants.

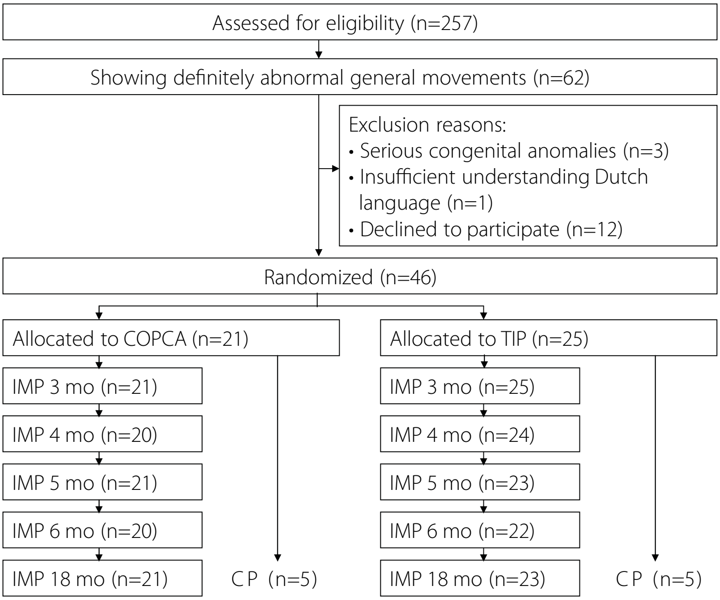

Figure 1: Flow diagram of participants of the Vroegtijdig Interventie Project (VIP). COPCA, COPing with and CAring for infants with special needs; TIP, traditional infant physiotherapy; IMP, Infant Motor Profile.

Table 1: Group characteristics for both the COPing with and CAring for infants with Special Needs (COPCA) and traditional infant physiotherapy (TIP)

	COPCA (n=21)	TIP (n=25)
Sex (n)		
- Male	9 (43%)	11 (44%)
- Female	12 (57%)	14 (56%)
Gestational age (n)		
- Preterm	19 (91%)	23 (92%)
- Term	2 (10%)	2 (8%)
Birthweight (grams)		
- Median	1210	1143
- Range	585-4750	635-3460
Brain lesion[a]		
- No severe brain lesion	18	22
- IVH grade 4 or PVL grade 3-4	3	3
Maternal education[b]		
- Low or middle	19 (90%)	14 (56%)
- High	2 (10%)	11 (44%)

Levels of education: low, primary education/junior vocational training; middle, secondary education/senior vocational training; high, university education/vocational colleges.

[a] IVH (Intraventricular haemorrhage), according to Volpe[17]; PVL (Periventricular leukomalacia), grading according to De Vries et al[18].

[b]Mann-Whitney U-test: p=0.013

In the TIP group, 21 infants continued with physiotherapy (all TIP; mean number of sessions 14), two infants did not receive physiotherapy between the ages of 6 and 18 months, and data were missing for two infants.

Measurements

The IMP assessment was carried out by one of the authors (CB-H) and Dr Victorine de Graaf-Peters, who were blinded to group status as part of an extensive assessment battery at 3, 4, 5, 6, and 18 months corrected age. The IMP is based on NGST. It is a video-based instrument used to evaluate spontaneous motor behaviour, applicable for infants from the age of 3 months until they have some months of walking experience. The IMP consists of 80 items organized into five domains: variation (i.e. the size of movement repertoire), variability (i.e. the ability to select motor strategies), symmetry, fluency, and performance. Items are scored in different positions, such as supine, prone, and sitting, and during reaching and grasping. The IMP results in five domain scores and a total score consisting of the mean of the domain scores. The reliability of the IMP is good.[12,13] The scoring of each IMP video was performed by two pairs of assessors blind to group allocation and previous IMP scores, either MD-M and MH-A, or TH and MH-A. Each person in the couple independently scored IMP items. In case of disagreement, scores were discussed until a consensus was reached. Interscorer agreement, assessed for TH and MH-A, was satisfactory for total IMP scores and domain scores, with intraclass correlation coefficients varying from 0.541 (domain symmetry) through 0.784 (domain variability), 0.799 (domain variation), 0.921 (domain fluency), and 0.944 (total IMP-score) to 0.995 (performance).

At 3 months, IMP data were available for all 46 infants. At 4, 5, and 18 months, the IMP data for two infants were missing, and at 6 months the IMP data for four infants were missing. Missing data were due to parental holidays or technical problems with the video.

All infants were neurologically examined with age-specific assessment techniques by one of the authors (CB-H) and Dr Victorine de Graaf-Peters, who were blinded to group allocation. Thus, the Touwen Infant Neurological Examination was applied at 3, 4, 5, and 6 months and the Hempel assessment at 18 months. At 18 months of age, the infants were classified as having either a normal neurological condition, simple minor neurological dysfunction, complex minor neurological dysfunction, or neurologically abnormal (development) – that is, the presence of a clear neurological syndrome such as cerebral palsy (CP). The reliability of the Hempel examination is satisfactory, but information on predictive validity is lacking.[16] For the two infants with missing IMP data at 18 months, the neurological examination was also missing. Therefore, it is unknown whether these two infants developed CP or not. One of them had no IMP assessment at 5 months. However, the other infants with missing IMP data did not develop CP.

Table 2: Total relative time spent on physiotherapeutic actions for infants with and without cerebral palsy (CP) for the family-centred COPing with and Caring for infants with Special Needs (COPCA) programme and traditional infant physiotherapy (TIP) interventions.

	COPCA, median (range)		TIP, median (range)	
	CP (n=5)	No CP (n=16)	CP (n=5)	No CP (n=16)
Facilitation	4,9 (0-9)	3,0 (0-43)	29 (14-55)	31 (12-64)
o Handling	1,8 (0-3)	0,9 (0-32)	14 (8-23)	17 (5-48)
o Pressure	0,0 (0-0)	0,0 (0-8)	4,3 (1-17)	7,7 (1-18)
o Transition	2,0 (0-3)	1,7 (0-5)	2,2 (2-11)	3,3 (1-16)
o Support device	0,0 (0-5)	0,0 (0-1)	0,0 (0-2)	0 (0-1)
Sensory experience	3,2 (1-11)	1,8 (0-5)	5,2 (3-7)	5,9 (0-23)
Passive experience	0,0 (0-2)	0,0 (0-1)	5,1 (0-11)	1,9 (0-13)
Spontaneous motor behaviour – no interference	32 (2-55)	45 (13-70)	25 (9-43)	17 (1-62)
Challenged to self produced motor behaviour – overflow into handling	0,3 (0-4)	0,0 (0-6)	4,4 (2-10)	7,4 (2-30)
o Little variation	0,2 (0-4)	0,0 (0-6)	3,5 (2-8)	5,2 (2-30)
o Large variation	0,1 (0-1)	0,0 (0-4)	0,0 (0-2)	0,2 (0-13)
Challenged to self produced motor behaviour – action continued by the infant	37 (18-61)	35 (19-61)	14 (4-30)	13 (2-35)
o Little variation	14 (3-25)	6,7 (0-34)	13 (4-24)	10 (2-21)
o Large variation	30 (5-36)	25 (3-42)	0,6 (0-7)	1,8 (0-22)
Family education	17 (8-32)	18 (0-37)	3,0 (2-15)	5,4 (1-30)
o Caregiver coaching	14 (7-31)	14 (0-36)	0,0 (0-1)	0,0 (0-0)
o Caregiver interferes with infant's actions	1,2 (0-3)	0,5 (0-3)	1,5 (0-1)	0,0 (0-1)
o PT guides infant	0,0 (0-0)	0,0 (0-7)	1,3 (0-2)	0,0 (0-7)
o PT interferes with infant's actions	0,3 (0-1)	0,3 (0-8)	1,8 (1-4)	2,2 (0-21)
o PT gives caregiver training	0,5 (0-2)	0,1 (0-1)	0,9 (0-8)	0,1 (0-5)
Communication	21 (8-29)	15 (0-43)	14 (9-48)	14 (1-40)
Contents of information				
o Handling	0,0 (0-0)	0,0 (0-0)	1,9 (0-7)	0,8 (0-10)
o Variation	2,0 (0-4)	1,0 (0-7)	0,0 (0-0)	0 (0-1)
o ADL handling	0,0 (0-0)	0,0 (0-0)	0,0 (0-5)	0 (0-5)
o ADL variation	0,0 (0-0)	0,7 (0-4)	0,0 (0-0)	0,0 (0-0)
Provide feedback	7,6 (1-11)	3,8 (0-13)	5,3 (3-6)	3,1 (0-17)
Information exchange	1,0 (0-6)	2,0 (0-26)	9,5 (1-19)	2 (0-22)
Instruct				
o Assign	0,1 (0-9)	1,2 (0-9)	0,1 (0-3)	0,2 (0-2)
o Give Hints	4,9 (3-6)	1,5 (0-7)	0,0 (0-1)	0,0 (0-3)
Impart knowledge	1,5 (0-4)	2,4 (0-11)	2,3 (1-12)	2,4 (0-8)
Not specified actions	4,6 (2-6)	2,9 (1-7)	5,1 (3-8)	3,0 (0-11)

Table 2: Total relative time spent on physiotherapeutic actions for infants with and without cerebral palsy (CP) for the family-centred COPing with and Caring for infants with Special Needs (COPCA) programme and traditional infant physiotherapy (TIP) interventions. (Continued)

	COPCA, median (range)		TIP, median (range)	
	CP (n=5)	No CP (n=16)	CP (n=5)	No CP (n=16)
Amount of support				
o No support	2,4 (0-22)	16 (7-28)	15 (5-23)	17 (2-40)
o Minimal support	9,2 (3-41)	21 (3-41)	4,5 (1-8)	4,3 (1-18)
o Clear support	18 (5-37)	17 (1-23)	12 (7-22)	21 (2-37)
o Full support	23 (3-42)	3,8 (0-24)	16 (4-47)	5,6 (0-30)
Imposed anteflexion of the pelvis				
o With anteflexion	0,0 (0-3)	0,0 (0-21)	13 (3-40)	15 (0-30)
o No anteflexion	39 (12-46)	41 (16-63)	32 (13-43)	35 (12-56)

Physiotherapeutic sessions were video recorded at 4 and 6 months corrected age. Video recordings were missing for three infants at 4 months (one from the TIP group; two from the COPCA group; none developed CP) and three infants at 6 months (one from the TIP group; two from the COPCA group; one developed CP) owing to logistical reasons (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010). Physiotherapeutic actions were classified by Lily Hulshof, a medical student undertaking a masters project and one of the authors (CB-H) according to the protocol developed by Blauw-Hospers et al.[11] using the computer programme Observer (Noldus, Wageningen, the Netherlands). In the protocol, all physiotherapeutic actions are defined. We recently reported that the inter- and intra-assessor agreement on assessment with the protocol are satisfactory: the intraclass coefficient of the relative duration of actions ranged from 0.76 to 1.00 for interassessor agreement and from 0.69 to 0.99 for intra-assessor agreement.[11] The assessors were blinded to the infants' group allocation, but it was inevitable that they got an impression of the type of intervention during classification. Examples of the physiotherapeutic actions described in the protocol are physiotherapeutic facilitation techniques (such as handling), spontaneous motor behaviour, communication actions, family involvement, and educational actions (see also Table 2). Observed physiotherapeutic actions were scored with a start and stop button, allowing for the calculation of total relative time spent on these actions. The actions for the two interventions differed substantially and, at 4 months, were largely comparable to those at 6 months (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010; Table 2). This was true also for the subgroup of children with CP (data not presented). Assuming that the two measurements at 4 and 6 months represented the actions during the intervention period better than a single measurement, we used the average of the 4- and 6-month values of the physiotherapeutic actions in the correlations with the IMP scores.

Statistical analyses

The power calculation was based on the total IMP score.[12] It indicated that two groups of 19 infants resulted in a power of 80% (a=0.05) to detect a clinically relevant change of 7.5 points (SD 8.2). Therefore, we aimed at recruiting at least 40 infants in order to be able to cope with attrition and loss of data. Statistical analyses were performed using the computer package SPSS (version 15.0; SPSS Inc., Chicago, IL, USA). Owing to the abnormal distribution of the data, non-parametric tests (Mann–Whitney U test) were used for intergroup comparisons. Differences with a p value of <0.05 were considered statistically significant.

Physiotherapeutic actions were correlated with the IMP scores at 6 months corrected age (i.e. at the end of the intervention period) and IMP scores at 18 months' corrected age (i.e. 1y after the end of the intervention) using bivariate correlations. Partial correlations were carried out using the control variables baseline IMP score, severe brain lesion (intraventricular haemorrhage grade 4[17] or periventricular leukomalacia grade 3 or 4[18]) and maternal education. Because of the probability of chance capitalization, correlations with a p value <0.01 were considered statistically significant.

In order to assess the effect of intervention between 6 and 18 months, we calculated relative IMP changes by dividing the differences in IMP scores between 6 and 18 months by the IMP scores at 6 months. The relative IMP changes were correlated with the number of physiotherapeutic sessions that the children received between 6 and 18 months.

RESULTS

IMP scores in the two intervention groups

Preliminary data analysis indicated that at 3 to 6 months infants with significant developmental problems scored too high on the domain variability. The overestimation was caused by inherent features of this IMP domain. First, items can only be assessed when a function is present. At an early age, the variability score is based on the performance of the head. The large majority of infants, including infants with neurological dysfunction, are able to make adaptive head movements. The items on adaptive selection of head movements are affected only in children with very severe disorders, resulting in lower scores in the domain variability. If other functions show a delayed development due to nervous dysfunction, the variability score is based only on head movement, which often results in an inappropriately high domain score. We therefore excluded the domain variability from the data analysis at 3 to 6 months. This implies that total IMP scores at 3 to 6 months were based on four instead of five domains.

The IMP domain scores and the total IMP score of the two intervention groups were similar at baseline at 3 months (Figure 2). Likewise, IMP domain scores and total IMP scores of the two groups did not differ during the intervention, immediately after the intervention (at 6 mo corrected age), and 1 year after the intervention (18 mo corrected age; Figure 2). The similarity of IMP scores in the two intervention groups was also found in the subgroups of children with and without CP. The relative IMP changes between 6 and 18 months were not associated with the number of physiotherapeutic intervention sessions between 6 and 18 months.

Neurological outcome

At 18 months, 10 infants were diagnosed with CP; five in the COPCA group and five in the TIP group. All had a spastic form of CP: two unilateral and eight bilateral. The Gross Motor Function Classification System levels[19] ranged from levels I to V: one infant was classified as level I (COPCA group), five as level II (two from the COPCA group; three from the TIP group), three as level III (one from the COPCA group; two from the TIP group), and one as level V (COPCA group). The last child also had significant additional impairments (visual impairment and epilepsy). Twenty-nine infants developed complex minor neurological dysfunction (13 from the COPCA group; 16 from the TIP group) and five developed simple minor neurological dysfunction (three from the COPCA group; two from the TIP group). Two infants had not been reassessed at 18 months (two from the TIP group).

Physiotherapeutic actions and IMP scores

Preliminary analyses indicated that correlations between physiotherapeutic actions and IMP scores differed for infants who developed CP (n=10) and those who did not (n=34; Table 2). The differences suggested that specific analyses for the two subgroups were required.

In infants with CP, physiotherapeutic actions were not related to IMP scores at 6 months. However, some physiotherapeutic actions were related to IMP scores at 18 months. Two COPCA-related actions were associated with positive outcome. First, the time spent during physiotherapy with caregiver coaching showed a positive correlation with the IMP domain variability (r=0.920; p=0.009). Coaching was defined as 'aiming to empower caregivers so that they can make their own decisions during daily-care activities in the home environment. The coach listens, informs, and observes (hands off), while the caregiver is involved in daily routines with the child, including play, thereby creating a situation in which the caregivers feel free to explore and discuss alternative strategies.' Second, time spent with challenging the infant to self-produced motor behaviour, continued by the infant with little variation, showed a positive correlation with the total IMP score (r=0.924; p=0.008). The total time spent with challenging the infant to self-produced motor behaviour (with little and large variation) just failed to show a significant association with the total IMP score (r=0.914; p=0.011). Finally, time spent with the TIP-related action sensory experience showed a negative correlation with the total IMP score (r=-0.969; p=0.001).

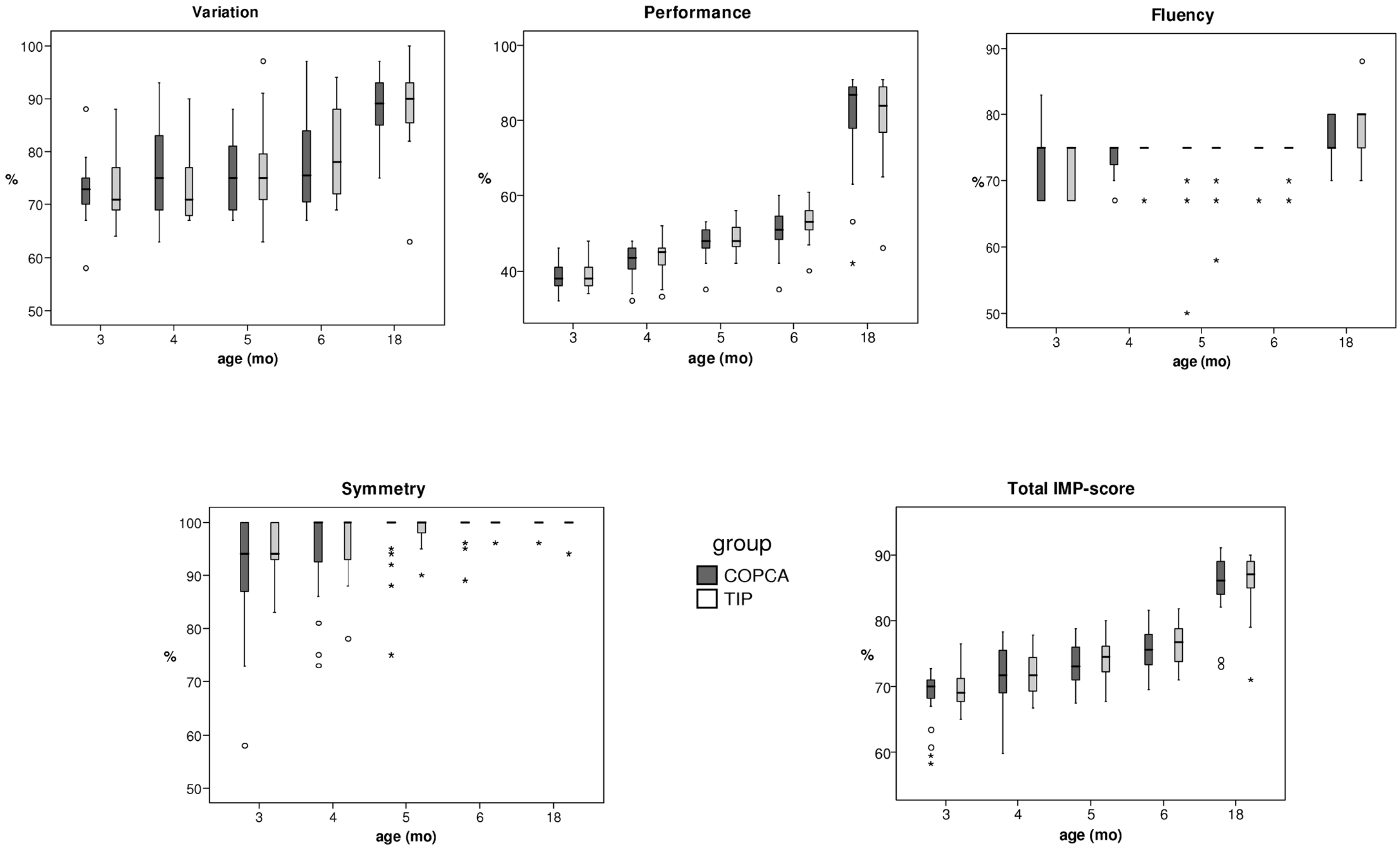

Figure 2: Infant Motor Profile scores for COPing with and CAring for Infants with Special Needs (COPCA) programme and Traditional Infant Physiotherapy (TIP) at the ages of 3, 4, 5, 6 and 18 months. Figures are boxplots. Straight lines mean that interquartiles and mean are the same.

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In the children without CP, only a significantly negative correlation between the action 'instruct by means of assigning' (i.e. the physiotherapist advises the caregivers what to do) and the domain fluency (r=-0.601; p=0.003) at 6 months was found.

DISCUSSION

At the level of the RCT, we found no difference in motor outcome between the two intervention groups. But the a priori scheduled analysis of the contents of physiotherapeutic sessions indicated that some COPCA-based physiotherapeutic actions in children with CP were related to better IMP scores. In contrast, some TIP actions were associated with worse IMP scores.

It may be considered a limitation of the study that only about a quarter of the infants developed CP, and the small size of the subsample makes it hard to draw conclusions regarding the effect of intervention in children with CP. Nevertheless, it is interesting that most significant associations between physiotherapeutic actions and outcome were found in this small subsample. The children who did not develop CP also showed neurological dysfunction in early infancy and, in general, also at the age of 18 months. Children with minor forms of neurological dysfunction may also profit from early intervention (Blauw-Hospers CH, Dirks T, Hulshof LJ, Bos AF, Hadders-AlgraM, personal communication 2010).

The fact that the IMP is a recently developed instrument is also a possible limitation. The present study indicated that the IMP domain variability cannot be used in infants at high risk for developmental disorders below and including 6 months' corrected age. On the other hand, the application of the IMP, which addresses the profile of infant motor functions, may also be regarded as a strength of the study. The IMP does not only provide information on more traditional aspects of motor behaviour, such as performance, symmetry, and movement fluency, but also on variation and variability. The last two domains are based on NGST,[8,9] the theoretical basis of the motor goals of the COPCA programme. It may, of course, be argued that we had a bias favouring the effect of COPCA and that this may have affected IMP scores. However, we tried to avoid this as much as possible by having different teams of assessors for the analyses of the physiotherapeutic actions and the IMP scores. In addition, all assessors were blinded to group allocation. The uniform neuromotor condition at the onset of intervention, that is, the presence of definitely abnormal general movements, enabled us to compare groups with similar clinical presentations at the onset of the intervention.

Systematic reviews and meta-analyses indicate that early intervention in high-risk infants has little or no effect on motor development. Some studies have indicated an effect on cognitive development, for instance the Infant Health and Developmental Program[20] has been associated with better outcomes at 24 and 36 months. Indeed, we found no effect on motor outcome at the level of the RCT in the VIP project, nor on secondary outcomes such as the Alberta Infant Motor Scales and the Paediatric Evaluation of Disability Inventory, but a minimal cognitive advantage was found for the COPCA group (Blauw-Hospers CH, Dirks T, Hulshof LJ, Bos AF, Hadders-Algra M, personal communication 2010). The limited effect on motor development may be based on neurobiological constraints, as animal studies have indicated that intervention after a lesion of the brain at an early age has considerably less effect on motor development than on cognitive outcome.[21] This implies that there are limitations to finding interventions that promote measurable functional changes in young children with evolving motor and developmental disabilities.

Another explanation for the absence of differences in outcome between the COPCA and the TIP group may be the heterogeneity in interventions, which makes it difficult to compare interventions at RCT level.[11,22] The detailed analyses of physiotherapeutic sessions enabled us to cope with the heterogeneity in paediatric physiotherapy[11] (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010). It revealed that time spent on physiotherapeutic actions was associated with motor outcome. We would like to stress that the relations found are associations and not causations. We controlled for factors that may have affected the associations, such as baseline IMP scores, severity of brain lesion, and maternal education, but it is conceivable that other aspects of infant–therapist interaction may also play a role. An ideal study design to evaluate the effects of COPCA would consist of an RCT in which COPCA would be compared with no intervention, but such a design is ethically unjustified.

The process analysis indicated that communication items were associated with motor outcome, that is, COPCA-related coaching was associated with better outcome and TIP-related instructing, by means of advising the caregivers, with worse outcome. Coaching aims to empower caregivers so that they can make their own decisions on what to do during daily care activities in the home (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010). In medical professions, the role of patients and professionals is shifting from a more paternalistic approach to a more 'shared decision-making' approach and a full family-orientated approach (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010). When clients are more involved in treatment and are in charge of decisionmaking, this could influence their sense of personal control, satisfaction with treatment, compliance, transfer into the daily routine of disease management, and, consequently, better outcomes.[23,24] The approach of coaching reflects an attitude of 'shared decision' or, even more so, 'parent-made decision', whereas the approach 'instructing by means of assigning' could be regarded as a sign of paternalism. In COPCA, coaching creates a process in which the family's needs and wants are translated into regular solutions on how to cope with the problems related to the infant's development from the family's own perspective, thereby creating a situation in which caregivers feel free to explore and discuss alternative strategies (Dirks T, Blauw-Hospers CH, Hulshof LJ, Hadders-Algra M, personal communication 2010). Coaching in COPCA also includes the provision of hints on how infant motor development may be promoted during family routines. Hints deal with how parents may challenge children's motor actions at the limit of their abilities and how to vary their motor activities. Interestingly, COPCA-related actions, with which the families became acquainted between 3 and 6 months corrected age, were not related to outcome at 6 months, but first with outcome at 18 months corrected age. This suggests indeed that the families had integrated into daily life certain strategies that fitted their own routines, thereby ensuring the provision of daily opportunities for the child to practise motor skills.

TIP includes optimization and normalization of functional activities. Interestingly, we found no positive associations between actions aiming at optimizing movement quality, such as handling techniques, and motor outcome. In contrast, the TIP action sensory experience was associated with worse outcome at 18 months. Sensory experience, such as massage, may be associated with accelerated development.[25] In our study,sensory experience was defined as tactile and vestibular stimulation of the infant with the aim of promotion of body awareness,[11] which means that it involved passive experience. Passive experience is known to be associated with considerably less cortical activity than active motor experience.[26]

Our findings are in line with those of Palmer et al.,[27] who reported that developmental outcome was better in children who received an infant stimulation programme than in children who had received intervention according to neurodevelopmental treatment. Also, the analysis of the associations between physiotherapeutic actions and secondary motor outcomes revealed that actions that were characteristic for COPCA were associated with better outcome at 18 months, and those that were characteristic for TIP, such as handling, were associated with worse outcome (Blauw-Hospers CH, Dirks T, Hulshof LJ, Bos AF, Hadders-Algra M, personal communication 2010).

In COPCA, motor goals are based on the NGST. They aim at enhancing the infant's motor repertoire (variation) and at the promotion of the selection of adaptive strategies (variability). We found associations between COPCA-based physiotherapeutic actions and variability in IMP scores (and also the total IMP score), but none between physiotherapeutic actions and variation. This suggests that it is harder to influence the size of the motor repertoire than the ability to select from the repertoire.

CONCLUSION

The present study suggests that elements characteristic of the COPCA approach, such as caregiver coaching and challenging the infant to self-produced motor activity, are associated with improved motor development and, in particular, with an improved ability to select the most adaptive strategy in a specific situation. The limited size of the present study stresses the need for more studies that evaluate the effectiveness of COPCA and other intervention programmes involving larger samples of children with CP. Sample sizes of such studies depend on the type of measure used to evaluate outcome.

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