ORIGINAL RESEARCH

Assisting the development of infants born prematurely using a self-regulation framework and relationship-based intervention process

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Abstract

Purpose: An intervention for improving the self-regulatory abilities of preterm babies over the first year at home is described and evaluated. Motor control was addressed as a significant aspect of regulatory competence. Parent concerns were addressed using video replay to establish parents' interpretation of infant behaviour.

Methods: LBW infants (< 32weeks; < 1500 gms) were randomly assigned into one of 4 blocks (control-intervention-control-intervention) along with a full term control group. Independent outcomes were conducted at 12 months.

Results: Preterm intervention (N = 24) scored significantly higher ($p < .001$) on Mental and Psychomotor Bayley Scales than preterm control infants (N = 22) though not as high as the full-term control group (N = 23). In motor development the largest gains were made by the most premature infants. The preterm intervention and full-term groups scored significantly higher on the HOME than the preterm control group ($p < .007$).

Conclusions: This model has implications for cost-effective practice by using key times for home visiting or community nursing to assist parents at home.

Key words

Premature, Clinical trial, Intervention, Relationships, Collaboration, Motor control, Maternal perceptions, Video-replay, Parental concerns

1 Introduction

The infant born prematurely is at risk for life long problems. With recent advances in high quality evidence, premature infants demonstrate continuing motor problems [1], learning difficulties at early school age, decreased attention, and decreases in executive function into their adolescent years [2]. The infants' difficulties are more likely due to differences in regulating their behaviour rather than a delay.

Babies born prematurely have difficulty with motor and state system regulation. For example, Field [3], cited difficulty in organising or modulating arousal as one reason why preterm infants were less playful. Gorga *et al.* [4] suggested another

reason may be difficulty in organising or modulating movement. They followed the development of motor function in premature infants over the first year and found that the infants did not develop a stable postural base from which to move smoothly and this could be expected to interfere with their ability to play. Follow-up studies suggested that motor regulation continued to be vulnerable, placing the children at risk for learning and behavioural problems at school [5]. Evensen and colleagues [6] have found that infants born prematurely continue to exhibit differences in motor development that affect coordination and balance skills at older ages.

These differences in regulation may be the reason why parents face a harder first year when their baby is born prematurely. Compared to infants born at term, infants born early are initially more irritable and take longer to settle into a routine [7]. They are less playful as 4 month olds [8], and parents face a longer wait for them to become mobile and play well on their own [9, 10]. Parents of premature infants initially report feeling helpless in their parenting role [11] and continue to perceive themselves as less competent and their infants more vulnerable as their children grow older [12, 13]. They also perceive their premature infants as more difficult and find them to have negative moods, be less adaptive and overall have more difficult temperaments [14].

Current interventions

An intervention to improve state and motor regulatory competence early would address the difficulties facing infants born prematurely and assist parents to settle in with their child. Some interventions have been developed in this direction. For example, Als [15] has developed a model of intervention for use in neonatal intensive care, the Newborn Individualised Care and Assessment program (NIDCAP). Infant progress was monitored using behavioural observations and written feedback was given to medical and nursing staff to help them recognise each infant's individual signs of stress and efforts at self-regulation. Staff used the feedback to monitor and modulate nursing care to reduce distress, promote stability and increase differentiation (eg smoother movement and state transitions; more robust states). This program of individual developmental support has been effective in improving medical outcomes in the nursery [eg, improved weight gain, weaning infants off oxygen support sooner] and in facilitating developmental outcome when assessed on both measures of regulatory and motor competence at 2 weeks and 9 months chronological age [16]. Als' NIDCAP intervention was not offered to parents in a formal program but it could be anticipated that parents learned some of the principles as they visited their babies in the nursery. The nursery environment and staff's interaction with the babies clearly acknowledged that infants' behavioural communications were meaningful and could be reliably used to guide care.

This paper describes a program of individual developmental care that was developed specifically for parents to use with their babies at home. The intervention called, "Developmental Care at Home" began just before the infant's discharge from hospital and continued over the first year. Recently, researchers [17] have, in principle, duplicated "Developmental Care at Home" but they did not describe the specifics of their intervention or obtain results that showed improvements in the infants' development (in their study, preterm control as well as preterm intervention infants scored in the normal range, which in itself is anomalous with the consistent body of research showing that infants born prematurely score more poorly and continue to be at risk for developmental problems). The purpose of this paper is to present the original intervention framework, developed and evaluated over twenty-five years ago but unpublished. This paper describes the intervention, based on improving self-regulation, the specifics of working with families and addressing their concerns, and includes the significant results from an independent assessment at one year of age (including comparison with a full-term control group that was missing in the Spittle et al study [17]). This paper addresses the question: under what conditions does early developmental intervention help infants born prematurely? The answer could have implications for community nursing and developmental support during 'universal home visiting' as proposed by Olds *et al.* [18].

The self-regulation model for intervention

The intervention was developed through the collaboration of two psychologists (RD and BW) and two physiotherapists (VM and JHO), based on Sroufe's [19, 20] self-regulation theory of individual development that identified three developmental issues or tasks for infants to master in the first year, with reciprocal supportive roles for the caregivers. The motor part of these developmental issues was elaborated by using Bly's [21] descriptions of the integration of extension and

flexion movements to promote stability before milestone development. Mahler's descriptions [22] of the "optimal physical distance" between the caregiver and infant at different ages, were used to understand the impact of the infant's motor behaviour on the developing relationship, and highlighted the physical role of caregiving through handling and touch.

Little has been written about supporting parent-infant relationships at the level of physical exchange. Beebe [23] has shown how the negative qualities of maternal touch at infant age 4 months significantly predict to insecure attachment at 12 months. Recently, researchers in attunement [24] have drawn attention to infants' emotional communication using whole body movements and how these induced a corresponding "affective echo" in those interacting with them. Downing [25] specifically asks what impact "muscular tightening", the stiffening up as infants are handled, has on the developing parent-infant relationship. In premature infant development, muscular imbalance makes stiffening a likely response to infant discomfort. When in their arms, parents may experience their infant's stiffening as their baby pushing away from them. If they interpret this as their infant not liking to be held, or not liking them, rather than as a cue for more physical support from them to return to a curled, flexed posture, one can see how misreading the infants' cues can negatively affect the developing relationship [26]. The conceptual model provided an informed practical base for exploring the meaning of these motor cues with parents and how parents might respond to them. It is only when you know how parents see the behaviour that you can find the language to share your insights with them.

Table 1. Summary of Self-regulation Intervention Model

Age in Mths	Developmental Issue	Role for Parents	Difficulties faced by preterm infants	Intervention principles informing individualized interventions		Expected Outcomes
0-3	**Return to Base** The infant's task is physiological stability or return to a base of flexed posture and calm (solid) states for sleeping, feeding and quiet alertness. *The motor challenge is to adopt a curled posture (of flexion) to balance extension activity.*	Setting Limits on extraneous movement and stimuli to help infants remain organized as long as possible. Focused *with* the baby – synchronous in attention and withdrawal.	Diffuse states, physiological and motor disorganization → difficulty with smooth state transitions	"Curling-in" → mothers "thinking flexed".	Parents as a buffer against stimulation, coming in early and persisting with containment.	(1) More regular sleep-wake patterns. (2) Infants feel cuddly when held. (3) Parents develop confident expectation that they can bring their infants back to a calm base.
3-6	**Taking the Initiative** The infant's task is to consolidate motor and state control for taking more initiatives in playful interaction, feeding and sleeping. *The motor challenge is to learn to hold body still in the midline by **actively** balancing the muscles of flexion and extension (around the major joints).*	Allowing infants to take more initiatives. Providing stable postural base for infants to move from. Parents confident they can bring their infants back to base when they overstep their limits. Sensitive to and co-operative with infants' cues →management of tension.	Over-use extension movement → less able to hold bodies in midline for controlled movement. Less robust states for play.	"Moving from a stable base" →mothers providing still base for infants to move from and return to.	"Going out with the infant", following their initiatives and "stepping in" if infant is over-loaded.	(1) More playful; independent in getting themselves off to sleep; and playing on own for short periods. (2) Infants respond preferentially to parents (3) Parents feel their baby knows them as a special person.
6-12	**Establishing an effective attachment relationship** The infant's task is to learn to use movement flexibly and attention flexibly to pause in play and "check in" with parents and physically come and go from parent. *The motor challenge is to move independently without losing stability.*	Being responsively available, giving an emotional and physical "scaffold" to support infants to come and go and play apart from parents.	Imbalance of muscle development → infants working hard to keep balance when on own; and little flexibility in moving independently – stuck in sitting or continually rolling.	Providing "physical scaffolding" → mothers physically assisting infants to move off from them confidently.	"Using parent as a secure base"→ watching child go out, noticing when they "check-in" and welcoming them back; joining with rather than directing play together; joining in unobtrusively when infant needs help on task.	(1) Move in and out from parent more smoothly. (2) Explore confidently. (3) Parents enjoy their infants' growing autonomy and find them less demanding.

The developmental issues for infants and corresponding tasks for caregivers at different stages are described in Table 1, with a brief account of the particular difficulties faced by infants born prematurely. The intervention principles around

each developmental challenge are also reported in Table 1. Success on each developmental issue was hypothesized to support the premature infant's flexible regulation of both movement and state control/attention. Table 1 provides a map for the intended process of intervention.

Framework for working with families: Addressing parents' concerns

Intervention addressed the needs of the individual mother-infant pair. The intervenor was an advocate for the infant and ally to the parent. The intervenor not only identified each infant's own efforts at self-regulation through self-regulatory assessments, but also discovered each mother's concerns and perceptions of her baby's regulatory efforts. Each intervention session began with the parent's concern or question, which is the basis for working collaboratively [27] and the heart of a family centred approach. Mothers then watched and commented on parts of video replays of each assessment so the intervenor could see through their eyes and hear about how they were making sense of their infant's behaviour. These intervention elements are consistent with Emde's [28] guidelines for successful infant mental health interventions. This intervention (1) addressed the experience of the infant and the mother (2) was developmentally oriented (3) focused on the infant-parent relationship and (4) involved the influence of relationships on other relationships.

Timing of intervention

Family contacts consisted of five or six visits [36 weeks, term, 1, 4, 6 and 9 months] over the first year, in contrast to programs where bi-weekly visits were common [29]. Assessment and intervention were targeted to come at the beginning of each developmental task, to evaluate each developmental spurt as underlying systems became disorganized and before new development was integrated. Brazelton [30] has suggested that these disrupted times just before change, are "touchpoints for development" and are key times to intervene. Thelen [30] presented a parallel concept called "phase shifts", where a period of integration is preceded by motor disequilibrium. These clinical windows of opportunity coincide with times when parents and infants are working hard on a problem and the intervenor can observe and support coping capacities of parent and infant. Patterson and Barnard [32] reviewed interventions for preterm infants highlighting the ongoing relationship between the intervenor and the caregiver as the most important factor contributing to intervention success and concluded that careful documentation of the intervention process could reduce costs and target interventions more effectively. In this paper, the procedures section illustrates intervention process.

2 Methods

2.1 Subjects

Infants and families were recruited from one regional tertiary referral Mother and Baby Unit (The Royal Hospital for Women) in an inner metropolitan area of Sydney, Australia and the project was approved by the Ethics Committee of the Royal Hospital for Women. Infants born preterm were eligible if inborn, less than 33 weeks gestational age, between 10 and 90% weight for age and with no congenital abnormalities. Infants were eligible for the full-term control group if vaginal vertex delivery at 38- 41 weeks gestational age, Apgars greater than 7 at 1 minute and 8 at 5 minutes, and spent no time in any intensive care unit. After confirmation of entry criteria, informed consent was obtained from the families.

The sample was recruited based on a sample size of 80 infants needed to detect a statistically significant difference and interaction effect at the $p < .05$ level on the five outcome variables selected. The final sample consisted of three groups of infants: preterm intervention (n = 27); preterm control (n = 27); full-term control (n = 27). Infants born prematurely were prospectively entered at the time of birth into four, 10-week blocks (control-intervention-control-intervention). Researchers selected block allocation to avoid contamination between the intervention and control groups and to ensure that, at any one point in time, mothers in the Neonatal unit had the same experience of either: (i) having their infants regularly assessed and followed up; (ii) or participating in a program based on these assessments. The full-term infants were recruited over the period that the preterm infants were enrolled.

Education levels for the parents ranged from those completing 4 years of high school to those completing a university degree. There were no differences between the groups in education level or socio-economic status based on public versus private hospital care and only one mother returned to full-time work during her infant's first year.

2.2 Measurement

Progress Measures used for Intervention process

All assessments were carried out at corrected ages. Progress in learning to regulate movement was assessed in the neonatal period by observing how the infant moved and returned to a still posture. This movement was expressed as a ratio of flexion to extension using an a-priori group of items that correlated to measure flexion and a similar group of items that correlated to measure extension (these items are available from the authors JHO and VM). The Meade Movement Checklist was used at 4 months [33, 34] and the Movement Assessment at 4, 6, and 9 months [35]. These assessments allowed intervenors an opportunity to observe typical, everyday handling by the mother. Progress in learning to regulate attention included the Neonatal Behavioral Assessment Scale (NBAS) [36] in the neonatal period and standardised play observations at 4 and 9 months (face-to-face play and the Kangaroo Box paradigm) [37]. All assessment results guided decisions as to how much help each infant needed to become more modulated during intervention.

2.3 Outcome measures

Staff who were blind to the infant's status, either full-term/preterm or intervention/control, performed outcome assessments at 12 months corrected age. The infants were assessed on the Bayley Scales of Infant Development to measure cognitive and motor milestones [38] and an observation procedure of function in upright (developed by VM and available by the author) that measured postural control [39]. Maternal sensitivity was evaluated using the HOME inventory [40]. The HOME is part interview, part observation and assesses the social and emotional support parents give their infants as part of day-to-day caregiving.

2.4 Procedures

After the initial session, assessments and interventions were conducted at home. In each intervention session, the intervenor (a) addressed each mother's concerns (b) assessed her infant to establish the modulation goal (c) ascertained the mother's perceptions of her infant's regulatory efforts by replaying video-clips of her baby's behaviour and asking the parent to comment (d) acknowledged the mother's question or concern and offered a developmental explanation for her infant's behaviours (e) described general intervention principles, made specific suggestions and (f) offered anticipatory guidance.

2.5 Structure of each visit

On arrival, the intervener would converse with the mother, using a semi-structured interview. The purpose was to: re-establish the relationship formed on the previous visit; gain an understanding of the infant's development in the intervening period; and ascertain the parents' concerns at this time by asking "What is the most difficult thing about your baby at this age?" and "What is the most enjoyable?"

Infant assessment followed with the mothers present and actively participating. Afterwards, mothers watched a video replay of the assessment and were prompted to give a commentary. Two video-clip segments were used each time; one highlighted the infant's efforts in interaction; the other drew attention to the infant's motor efforts during something physical, like steadying his/her body to attend, reaching to a toy, or making an effort to roll over. The segments were chosen to look at the infant's best regulatory efforts. Mothers were asked to describe when their infant looked comfortable and times when he or she began to appear stressed. They pointed out observed behaviours that influenced their descriptions. This intuitive "mother knowledge" was integral to the intervention because the mother's personal understanding of her baby determined how the intervention was framed. The intervenor confirmed the mother's observations

and reflected with her about what she was already doing and what else she could do to support her infant's efforts. Suggestions for handling, which aimed to help the infant become more modulated, addressed what the mother was concerned about and were introduced using terms that made sense to her.

The following case example illustrates the intervention process.

Case example in the neonatal period:

Mother's concern: The infant was born 9 weeks early and weighed 1600 grams at birth. She was discharged from hospital just before 36 weeks gestational age. The mother's main concern was that her baby was "windy" or colicky. The mother explained that after a feed her infant made straining sounds and seemed uncomfortable and took a long time to settle to sleep. The infant's grandmother had also noticed the infant stretching out with her legs as she strained and suggested that the infant was trying to stretch out to pass wind. Consequently, the mother had stopped wrapping her infant to allow her to stretch or extend more.

Assessment: On the Brazelton assessment, the infant remained in a low-key alert state. She was not very active but in response to stimulation she would squirm and push into extension and begin to strain. The extending could be contained by helping the infant curl-up on her side. In this position the infant slowly relaxed and stopped straining and could move into a solid sleep state.

Modulation goal: To help the infant to develop solid states and move smoothly between them and to develop the flexed postural base to manage these transitions.

Mother's perception of her infant's regulatory efforts: On the video replay, the mother paid great attention to her infant's movement. She pointed to subtle signals from her baby indicating when she was relaxed and comfortable and when she was not. "If she's having problems she throws her arms up and grasps with her hands"; "when she's upset she jerks her arms". "Look how floppy she is when she's tired". "She brings her hands to her face maybe as a comfort. She's done this a lot since she was born". "Her mouth looks nice and soft when she's relaxed". "She's really relaxed when she's not moving much". She observed that each time her baby was handled curled-in on her side she stopped straining. When asked why she thought this helped, the mother said "Because it's the fetal position and she feels secure".

On another part of the tape, the mother commented that her infant needed to feel secure before she could become alert. She described how her infant really seemed to listen when she curled her in against her chest and talked quietly to her, whereas if she tried to talk to her when holding her out she squirmed and turned away. There were times when her baby "fought against" her and really did not want to be held. This would happen at feed times. "Then I think she doesn't like me," she said.

Feedback: Mother's Task: The challenge for the mother was to be able to firmly contain her infant when the baby was tired or needing to focus her energy for feeding. In the intervention session the staff member first confirmed the mother's observations that the baby's movement signals were her most reliable means for communicating how she was feeling. The staff member acknowledged that the baby's "pushing away" could feel rejecting to the mother. Then she offered a developmental explanation for this behaviour in terms of the imbalance between flexion and extension and the baby's difficulty in regulating this balance when tired.

Specific handling suggestions: The staff member discussed with the mother ways to help the infant feel secure around feed-times and when going to sleep. The first suggestion was wrapping the infant to help her curl-in. The staff member explained that in this position the infant would also pass wind more easily.

The mother practised the wrapping technique on a baby-sized doll until she felt confident with it. She then wrapped her infant and when her infant was relaxed she loosened the wrap over her legs, leaving her shoulders curled in. She fed her in

this curled-in position. The mother noticed the baby sucked more strongly and did not push back in this position. After the feed, she wrapped the infant curled-in again and held her still against her. With the staff member's encouragement, she kept holding her baby still until she could feel her physically relax. The infant stopped making straining sounds and, to the mother's delight, settled into a calm sleep. Having maintained her help until her infant reached a solid sleep state, the mother was then able to transfer the infant to her bassinette without her waking up. Thus the mother learnt to recognise the difference between diffuse and solid states and how to give her infant the postural base to effectively calm. She did all this with the intervenor present so that she had back up.

General principles: As a general principle the mother was encouraged to "think flexed". The staff member gave her some suggestions, for example, showing her how to curl her baby onto her body when picking her up or putting her down so as to help the infant feel secure when being moved. She was also shown how to carry the infant tucked into the crook of her arm to help her mould-in. These lift and carry positions gave the infant many opportunities to practice flexion movement. The mother came up with ways to create a flexed posture when she wasn't holding her, like wrapped in the bouncinette or "nested in" by placing a pillow under her knees.

The handling suggestions made sense to the mother. She was sensitive to protecting her infant from too much stimulation. For example, by darkening the infant's room and keeping things quiet at sleep time. However, she had not been able to provide the same containment physically, nor been aware that such containment would help her little girl achieve a deeper, less noisy sleep. She now knew at first hand what it felt like to have the baby relax into her body and she knew how to recreate this; she also had a developmental story to share with members of her family instead of feeling adrift and confused by her family's different views on the baby's needs.

Anticipatory guidance: Before leaving, the staff member discussed with the mother appropriate guidelines for how much sleep her infant needed and suggested that as the infant got more organised with her sleep, the infant would be more successful with demand feeding.

3 Results

Subjects: The sample size for all analyses is 69 (Preterm control = 22; Preterm Intervention = 24 and Full-term control = 23). Three families moved inter-state prior to the 12-month assessment and so lived too far away to participate. One child was in plaster casts to correct hip dysplasia. Eight infants were excluded from the outcome analyses because they were receiving therapy for specific developmental difficulties, eg cerebral palsy. Four of these infants came from the preterm control group and two each from the preterm intervention and the full-term group.

3.1 Analysis of background factors

A series of one-way anovas compared the three groups on gestational age and birth weight. Pairwise comparisons of the means showed that the two preterm groups did not differ significantly from each other on these factors and the full term group differed significantly from both groups (see Table 2).

Table 2. Means, standard deviations and ANOVA for background factors by group

	Preterm Intervention (n = 24)		**Preterm Control (n = 22)**		**Full-term Control (n = 23)**		***F*** **df = 2, 68**	***p*** **<**
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**		
Gestational age	29.9	(2.2)	31.1	(2.1)	39.8	(1.0)	222.6	.0001
Birthweight (grams)	1434.6	(338.6)	1638.4	(425.7)	3501.5	(345.0)	253.3	.0001

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3.2 Analysis of main variables: HOME scale

One-way anovas were used to compare the three groups on the Home Observation for Measurement of the Environment (HOME). Mean total HOME scores for the preterm intervention group were similar to those of the full-term group (F = 5.4, $p < .007$). Both groups scored significantly higher than the preterm control group. When HOME component scores were considered separately, the group differences were marginal for Emotional and Verbal Responsivity (EVR) (F (2, 68) = 3.3, $p < .045$) and significant for Maternal Involvement with Child (MIC) (F (2, 68) = 8.9, $p < .001$). Longitudinal studies have found this scale to be associated with gains in cognitive and language development in childhood (see Table 3).

Table 3. Means and standard deviations for HOME scores by group

	Preterm Intervention (n = 24)		**Preterm Control (n = 22)**		**Full-term Control (n = 23)**		***F* df = 2, 68**	***p* <**
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**		
HOME Total Score	36.7	(4.6)	33.0	(5.4)	36.7	(3.5)	5.4	.007
Emotional and Verbal Responsivity (EVR)	9.4	(1.9)	8.4	(1.9)	9.5	(1.3)	3.3	.045
Maternal Involvement With Child (MIC)	4.5	(1.4)	2.8	(1.5)	4.1	(1.2)	8.9	.001

3.3 Analysis of main variables: Bayley scales

One-way anovas compared the three groups on the Mental Scale and the Psychomotor Scale of the Bayley Scales of Infant Development. There were significant group differences on both the Mental and the Motor scale, with the preterm intervention group being intermediate between the preterm control group and the full-term control group (Mental scale F (2, 68) = 10.5, $p < .001$; Motor scale F (2, 68) = 10.1, $p < .001$). Results of multiple comparisons, using the Bonferroni method to adjust the significance level for each comparison, established that the groups differed significantly from each other. Specifically, preterm infants in the intervention group achieved significantly higher Mental and Motor scores than preterm infants in the control group but did not score as highly as full-term infants (see Table 4).

Table 4. Means, standard deviations and ANOVA for Bayley Scales scores by group

	Preterm Intervention (*n* = 24)		**Preterm Control (*n* = 22)**		**Full-term Control (*n* = 23)**		***F* *df = 2, 68***	***p* <**
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**		
Mental Development Index (MDI)	108.1	(11.3)	99.7	(12.5)	116.4	(12.8)	10.5	.001
Psychomotor Development Index (PDI)	87.7	(14.3)	78.8	(10.8)	100.0	(20.8)	10.13	.0001

3.4 Analysis of function in upright

Results on the Function in Upright procedure showed that the motor gap between the preterm intervention and full-term group closed when postural control or assessment of motor control was considered. Intervention infants demonstrated significantly more flexibility in their movement than the premature controls and were not dissimilar to the full-term infants, F (2, 64) = 6.39, $p < .003$ (see Table 5).

Table 5. Means, standard deviations and ANOVA for Function in Upright test by group

	Preterm Intervention (*n* = 23)		**Preterm Control (*n* = 21)**		**Full-term Control (*n* = 21)**		***F* *df = 2, 64***	***p* <**
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**		
Function in Upright Test scores	34.3	(15.8)	24.3	(12.0)	41.8	(17.0)	6.39	.003

3.5 Comparison between younger and older gestational age infants

The effect of intervention was explored further by investigating whether intervention had a greater effect on infants of younger gestational age. The preterm sample was divided into two groups, with one gestational age less than 31 weeks (Younger Gestational Age group) and the other with gestational age between 31 and 33 weeks inclusive (Older Gestational Age group).

The data suggest that the effect of intervention is the same for the younger and older gestational age infants for the Mental Development Index (MDI) but different for the Psychomotor Development Index (PDI). On PDI, intervention appears to have little effect for the older gestational age group, but a large effect for the younger gestational age group. Two-way anovas were used to assess the significance of the interaction in each case. For the MDI it was not significant (F (1, 42) = 0.19, ns). The interaction was significant for the PDI (F (1, 42) = 5.96, $p < .02$). Therefore, intervention was associated with gains in mental development for all gestational age infants. However, it had a differential impact on motor development; here infants born at the younger gestational ages were the ones to benefit most (see Table 6).

Table 6. Means and standard deviations of MDI and PDI scores by gestational age and group

	Younger Gestational Age Group (<31 weeks GA)				**Older Gestational Age Group (31-33 weeks GA)**			
	MDI		**PDI**		**MDI**		**PDI**	
	Mean	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**	**Mean**	**(SD)**
Preterm Control (n = 22)	98.8	(11.6)	71.4	(7.4)	100.2	(13.3)	83.1	(10.3)
Preterm Intervention (n = 24)	106.2	(8.7)	90.8	(13.1)	110.4	(13.9)	84.0	(15.5)

a. Group effects were significant for both X and Y:
MDI: F (1, 42) = 6.09, p < .02
PDI : F (1, 42) = 9.05, p < .02

b. And the interaction effect between group and gestational age was significant for PDI only:
PDI: F (1, 42) = 5.96, p < .004

4 Discussion

The program was successful in enhancing both maternal sensitivity and infant development at one year of age. The question posed, "Under what conditions does early developmental intervention help infants born prematurely?" is answered by the following three benefits. First, the results were positive because the intervenor worked within the *individual parent-infant relationship.* Second, intervenors used a *conceptual framework* based on *self-regulation* to drive the intervention, which included a *framework to address parents' concerns* (including assessing each mother's perceptions of her infants' regulatory efforts so that the intervention could be framed around her personal understanding of her infant). Finally, the *timing* of interventions was during key times or "touchpoints" in development.

4.1 Development as a relational process

The primary benefit of the self-regulation model was its emphasis on development as an *relationship-based process.* In practical terms, the focus was on what the baby and parent could do together, not on what the infant was not achieving or the parent did not understand. In self-regulation assessments (like the Brazelton scale), the examiner is defined as the natural advocate of the baby. As the examiner, you are working with the baby and attending to how *you* can modulate and change what *you* do, so as to help the infant function more smoothly. Watching an examiner work in this way, confirms for parents that their infant's behaviour is meaningful and important to respond to with their own caregiving [41].

4.2 Conceptual framework for intervention

The conceptual framework, based on a self-regulation model, gave intervenors a clear understanding of premature infants' needs. Because this framework measured underlying processes, intervenors could identify and address difficulties that would likely continue as problems.

This conceptual model met the mother's concerns. Each intervention session began with the parent's concern or question, which is the basis for working collaboratively [28]. Mothers rarely mentioned delay as a concern (6%); instead their focus was on ordinary day-to-day issues like calming and settling the infant in the newborn period. The self-regulation model clearly provided practical solutions for these concerns. The intervenor used this model to focus on the contribution of motor behaviour to the developing parent-infant relationship and perhaps this explains why the intervention was particularly successful in enhancing motor development in the most immature infants. This finding is in sharp contrast to the generally poor record of intervention in improving motor development [41].

There were two specific differences between this study and the recent study by Spittle *et al.* [17] which showed no differences in developmental skills; the use of video clips as a component of the intervention process to learn about the mother's understanding of her infant's cues (including motor signals), and practical motor interventions. In this program, the motor goal was to establish a stable, postural motor base from which to move. Researchers [42] have suggested that this foundation in fact operates throughout childhood. Premature infants often use too much movement to initiate an action [44]. The motor component in the conceptual model and in the video segments enriched what the intervenor and parent could explore together. They could attend to subtle motor cues from the infant that might otherwise go unnoticed or be misunderstood [27]. Instead the mother could consider these cues with someone and reflect on how she might do things differently with her body like the way she held her baby, in order to foster a closer connection and support her infant to be a competent interactive partner. Downing [26] has used video to help clients in distressed relationships to explore what usually is felt bodily but not seen in 'real-time' in the constant exchange of signals when a mother and infant are relating to each other.

4.3 Benefit for younger infants

The mothers of the younger infants may have faced a more difficult task in settling in with their babies. Als [45] found that infants born earlier were more sensitive to stimulation and handling and showed their distress through physiological instability and motor disorganisation, becoming more active when held, arching and then quickly becoming floppy. Parents of such immature infants can feel that their small babies do not like to be held or are too vulnerable to be held often. This intervention, with its special focus on motor regulation and how differences in motor behaviour can affect the quality of the parent-infant relationship, may have had more practical relevance to mothers of these younger gestational age infants.

In the intervention group, one striking consequence of wrapping the babies curled-in was that, as they relaxed and curled forward in their wrap, they felt cuddly to hold. Later, when unwrapped, the infants were able to maintain this curled posture for some time. When they did move, it was from a flexed position so that they were more likely to cycle in their movements rather than become bouncy, extended and overly active. Consequently, they could better tolerate procedures like being changed and dressed. Because the younger infants were initially so motorically vulnerable and the consequence of wrapping and holding so dramatically effective in calming and containing them, the mothers were rewarded with success. This success may have further promoted mothers' confidence and pleasure in holding their infants and made them more receptive to later developmental guidance, including encouraging the mothers to respond to the infants' efforts to try to move themselves, such as helping the infants push themselves into sitting between six and nine months of age.

4.4 Timing of intervention

A third benefit of the model was that interventions could be targeted to sensitive times, or "touchpoints" [30, 31]. The contacts were planned to coincide with times when infants began to address new developmental issues and parents

therefore faced new tasks. The content of intervention was specifically geared to helping mothers understand each new developmental task and "grow" with their infants' new challenges. By specifying key times to intervene this model can be presented in as little as 6 visits over an infant's first year, allowing for cost effective follow-up and parent-infant support.

Effective parent-infant interaction is well established as the strongest factor working to override the early negative consequences of prematurity [46, 47] and the significant results on the HOME scale illustrate mothers' increased sensitivity to their babies in the intervention group. The developmental psychologists worked within the parent-infant pair to support the competence of the pair, which promotes enduring gains in infant ability [48]. In this intervention the intervenor's relationship with the mother may have served as a "metaphoric parallel" [49] for the mother's responsiveness toward her infant. The intervenor asked for and respected each mother's perceptions and feelings about her baby. As their own understandings of their baby were taken into account and their strengths were recognised, mothers may in turn have been more able to recognise and respond to the needs and strengths in their infants.

4.5 Clinical implications

Dovetailing of the two disciplines, physiotherapy and psychology formed a coherent clinical intervention model focused on the interactive process between parents and their vulnerable infants. Other allied health personnel could use this model during clinical follow-up, parent support, community nursing or universal home visiting.

4.6 Limitations

The preterm intervention was conducted in four blocks (control-intervention-control-intervention). Full term infants were enrolled into the project over the period that preterm infants were enrolled. The decision was taken to enrol in blocks instead of a traditional randomized trial due to the constraints of the nursery environment. The conceptual framework is based on building good foundations for later flexible functioning, therefore longer follow-up would have been preferable to determine if the children had fewer motor and attention problems in later years.

5 Conclusion

This paper has described and evaluated a model of intervention for improving the self-regulatory abilities of preterm infants over the first year. In this model, motor control was addressed as a significant aspect of regulatory competence. The content and timing of intervention was driven by a coherent conceptual model drawn from developmental psychology and paediatric physiotherapy. The model included a framework for working with families to address their concerns. Video replay of sections of the infant assessments were used to establish the parents' interpretation of their infants' behaviour so that intervention ideas could be framed in ways that made sense to parents. The program was successful in facilitating maternal sensitivity, cognitive and motor development, particularly for the most immature infants. In motor development the largest gains were made by the most immature infants (GA less than 31 weeks). These results endorse a self-regulation model of intervention as able to meet infant developmental needs and parent concerns. By specifying key times to intervene, allied health professionals including nurse practitioners and community nurses can influence cost effective practice.

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