Infants who are born prior to forty weeks gestation frequently demonstrate a rate of development which is different from that evidenced by their term born peers. This is true particularly for those infants who have no abnormalities which would interfere with their development but who are both very preterm (of 32 weeks gestation or less) and of very low weight at birth (1500 grams or less). Stimulation aimed at overcoming the negative aspects of preterm birth and enhancing the development of preterm born infants has been widely recommended. The evidence which supports the idea of such intervention is conflicting and based on inconclusive data.

The purpose of this review is to identify those aspects of early stimulation programmes which have been of measurable benefit to preterm born subjects. From this basis it should be possible to isolate optimal forms of stimulation to guide those who seek to provide these infants with assistance designed to maximize their developmental potential.

The ontogenetic progression through infancy and childhood of the term born infant is well documented and generally proceeds with few deviations (Prechtl 1981). Knoblock and Pasamanick (1974) have suggested that the behaviours (that is the observable responses displayed by the infant and young child) are the manifestations of the dynamic processes of change which the infant experiences as it progresses towards increasingly more mature capacities. The evaluation of the degree to which the infant is attaining the various stages which characterize this changing process is an indication of the level or status along the developmental continuum which the infant has reached. This dynamic process of change is termed development.

Birth before the completion of the full gestational period interrupts the usual course of development. For those infants who are described as very preterm, that is those born at 32 weeks gestation or less, and of very low birth weight (VLBW), weighing 1500 grams or less at birth, developmental process or status is a matter of interest to physiotherapists. Such infants are considered to be at greater risk for the appearance of pathologies likely to interfere with the emergence of normal motor patterns. The increasingly mature behaviours which characterise the development of the term born infant are likely to be slower to emerge in very preterm, VLBW infants leading to delays in the achievement of commonly recognized abilities.

The discrepancy between the behaviours displayed by very preterm, VLBW and term born infants, particularly in the early months of life has resulted in proposals for various forms of compensatory management. The absence of the cyclic stimulation provided by maternal rhythms of sleeping and waking, movement and noise has directed attention to the need to consider sensory inputs experienced by the preterm born infants more carefully.

Two points of view are most frequently expressed. The first suggests that the infant of short gestation suffers from sensory deprivation (Field 1980, Katz 1971), the second that overstimulation provided by the complex equipment surrounding the infant and the repeated noxious procedures to which the infant is exposed, create a level of stress which the infant is ill-equipped to manage (Campbell 1986, Touwen 1980). Both viewpoints have generated models of management.

The programmes designed to offer supplemental stimulation have taken various forms. Not only are different types of intervention prescribed, but the time of implementation varies considerably. The suggested management has been offered during the period of the initial hospitalization or following discharge, either as a home based programme or as a regular consultation with a member of a follow-up team. The purpose of the review presented here is to examine the value of the

various intervention programmes described in the literature with a view to identifying those procedures which have been reported as being most beneficial to the very preterm born infant.

**Intervention Prior to Hospital Discharge**

Professionals from several different disciplines have reported on the efficacy of particular interventions offered within the nursery environment. The majority of the earlier descriptions are of programmes which have not been based on physiotherapy principles. Reports detailing the content and effectiveness of intervention designed by physiotherapists tend to have been published more recently.

**General Programmes**

Programmes which provide added sensory stimulation are described most commonly. Simple stimulation of the somatic tactile sensory system by means of stroking has not been shown to be beneficial (Solkoff et al 1969, Kramer et al 1975). Stroking which was described as gently rubbing the infant’s neck, back and arms every hour for five minutes over a ten day period was administered soon after birth by Solkoff and colleagues (1969) to normally developing infants weighing between 1190 and 1590 grams. A control group received normal nursery handling such as feeding, diaper change and routine observations. The startle response, daily weight changes, temperature, intensity of cry and vigour of accompanying movements, frequency of urination and defaecation, and physical development at six to nine months after discharge from hospital were all monitored. Unfortunately, the small sample size did not permit statistical analysis, and the study provided only subjective indications of more rapid weight gain and less crying in the experimental group. At the nine months evaluation, the authors suggested that the experimental group fared better on the Bayley Scales of Infant Development (BSID, Bayley 1969). Again, since no data were provided, the study offers no insights into the value of tactile stimulation as a form of intervention.

A later report by Kramer et al (1975) of a programme of tactile stimulation administered to 14 infants of less than 38 weeks gestation produced no results of significance. The study defined the intervention as consisting of gentle stroking offered both before and after feeding for a total of approximately 48 minutes per day and extending from birth until transfer from an isolette. Immediate effects were measured by the administration of the Gesell Developmental Schedule (Knobloch and Pasaminick 1974) at the time of transfer to the isolette. At six weeks and three months the BSID (Bayley 1969) was employed to identify group differences. No significant differences between the experimental and the control group were reported, and weight gain was similar for both groups. The study had intrinsic problems because the subject population was recruited from seven different hospitals and, despite efforts such as time sampling to ensure that the care in each nursery was constant, this represented a major methodological difficulty.

One approach to the problem of overstimulation of the tactile sensory mode has been to use a constant stimulus such as is provided by a lambswool mattress cover. Scott and Richards (1979) examined the effects on daily weight gain and the amplitude and frequency of movement of introducing such a change on the 27th post natal day to six symptom free infants of mean birth weight 1369 grams. The mattress was covered alternatively with either cotton or lambswool for 24 hour periods over four days. Weight gain was significantly greater on the days lambswool was used and, at the same time, an increased frequency of small amplitude movements and decreased frequency of large amplitude movement was observed. None of the other parameters measured, such as cot temperature, bowel motions or amount of milk ingested, altered during the period of the study. The greater weight gain (a mean of 31.5 grams versus 19.6 grams) was attributed to several factors. A reduced oxygen requirement could have been associated with the diminished movement, and the diminished movement may have contributed to reduced radiant heat loss. Equally, the texture of the lambswool may have been more soothing to the infant, as was the Terry toweling covered surrogate mother to the isolated infant monkeys in the experiments described by Harlow and Harlow (1966).

It appears that tactile stimulation in the form of stroking of the limbs and trunk has not been demonstrably beneficial. It could be argued that the absence of effect may have been related to the type of tactile input offered. According to Rood (1962), to produce a calming effect, tactile stimulation should be performed slowly with maintained pressure. If the stroking offered the infants in either of these studies was closer to a phasic form of stimulation, it would be an appropriate use of this sensory modality. Equally, this suggestion may explain the success of the lambswool mattress covering. Of course, the decreased oxygen requirement could be sufficient explanation in itself. However, the maintained, evenly distributed tactile stimulation offered by the lambswool may have produced a more settled infant by replacing the intense level of tactile stimuli offered by the rougher cotton surface.

The supplementation of tactile stimulation with an additional sensory modality has been shown to produce positive clinical effects. However the statistical significance of the reported results has not been established conclusively. The specific effects of tactile and visual stimulation used both in isolation and in combination were examined in a study reported by Hayes (1980). The low birth weight subjects (LBW, that is infants whose birth weight was 2000 grams or less) in this study were randomly assigned to one of three experimental groups and a control group. Infants in the experimental groups experienced a programme of both visual and tactile stimulation or only visual and only tactile supplementary input. The tactile stimulation involved stroking for periods of up to a total of 90 minutes per day and the visual stimulus was provided by mobiles and bright stickers placed around the incubator or crib. Hayes (1980) indicated that a positive treatment effect related to
visual attention was found prior to discharge from hospital. It was not reported whether this outcome was the same for each of the experimental groups, thus the value of the study in isolating the two sensory modalities was not fully realized. The principal importance of this investigation was contained in the report of the comparative developmental status of the participants at three years of chronological age. All the female subjects from all the stimulated groups and the control group performed as well as a similar cohort of term-born infants on the McCarthy Scales of Children’s Abilities (McCarthy 1972) when tested at three years of age. Male subjects who had received stimulation also performed equally as well as their term-born peers, but unstimulated male subjects were significantly less competent. This appears to be the only report of a difference in the influence of stimulation related to the sex of the infant.

The combination of tactile stimulation with kinaesthetic input was reported by Field et al (1986), Rausch (1981) and White and LaBarba (1976). The short term outcome resulting from the application of massage and passive movements to the extremities was selected for investigation by White and LaBarba (1976). Twelve normal preterm infants, aged less than 36 weeks and weighing between 1588 and 2040 grams who came from families of low socioeconomic status (SES) were enrolled in the study. The programme was administered for 15 minute periods every hour for four consecutive hours over eleven days from the time the infant was 48 hours old. The intervention was judged to be a success because of the 13.9% increase in weight demonstrated. Rausch (1981) evaluated the influence of a daily programme which consisted of five minutes of passive movements of the limbs preceded and followed by a five minute period of massage. This study revealed a statistically significant increase in the frequency of bowel motions, the daily caloric intake and daily weight gain of the experimental group which Rausch (1981) has attributed to the effect of the supplementary handling programme on vagal stimulation. However, the results need to be viewed with caution as the matched control group employed in this study was retrospectively selected from infants who had been admitted to the same nursery prior to the birth of those in the experimental group, thereby creating some methodological difficulties.

The financial significance of stimulation programmes which increase weight gain was identified by Field et al (1986) as an important consideration. These authors examined the effects of a mixed tactile and kinaesthetic programme which was tested on 40 infants with a mean weight at birth of 1280 grams, a mean gestation of 31 weeks and a mean length of stay in the neonatal intensive care unit (NICU) of 20 days, who were randomly assigned to either the experimental or the control condition. Significant differences were reported for several dependent variables. These included weight gain, the duration of awake/alert periods, the Neonatal Behavioural Assessment Scale (NBAS, Brazelton 1973) and length of hospitalization. As a result of a 15 minute period of stroking and passive limb movements repeated over three consecutive hours for a ten day period, the infants in the experimental group were discharged an average of six days sooner than the control infants. Field et al (1986) estimated the resultant saving as US$6000.00 per infant.

Since tactile stimulation in the form of stroking has not been proven to be beneficial, it is very likely that the positive effects demonstrated by the mixed tactile and kinaesthetic programmes were largely a result of the kinaesthetic stimulation, or the increased opportunity for movement which was provided, incidently, by the passive movements performed. However, as Ross (1984) has explained, no specific guidelines for the most effective form of stimulation for either of these sensory modalities can be identified from the available research evidence.

Stimulation of the vestibular system as a means of producing short term benefit in preterm born infants has been extensively studied. The idea developed from the results of beneficial effects found in young rats (Thoman and Korner 1971) and term born neonates (Gregg et al 1976, Korner and Thoman, 1972). The rationale for this form of intervention has been described by Korner (1979) as a deficit offsetting model designed to reduce the negative influences of immobility and loss of normal, maternally provided stimulation. The use of this mode of sensory input has been frequently reported (Korner et al 1975, Kramer and Pierpont 1976, Edelman et al 1982, Korner et al 1983, and Pelletier et al 1985). The stimulation has been provided by the use of a water-filled mattress which can be oscillated cyclically. The principal benefits demonstrated by this form of stimulation include a reduction in episodes of apnoea (Korner et al 1975), an improved capacity to attend and to pursue animate and inanimate auditory and visual stimuli, more mature movement patterns and a reduced irritability and hypertonicity in infants with respiratory distress syndrome (Korner et al 1983). It has been suggested that the waterbed experience may contribute to the maturation of functional ability which in turn would enable the infants to be more available to appropriate environmental stimulation (Korner et al 1983). Pelletier et al (1985) reported also that infants placed on waterbeds following stressful nursing procedures demonstrated more self-calming behaviours and significantly fewer signs of stress than controls placed on regular incubator mattresses. However, the significance of this form of stimulation for subsequent developmental status has not been investigated.

An alternative means of delivering vestibular stimulation is through the use of a hammock. Neal (1975) examined the differential influence of imposed or self-activated vestibular stimulation on a group of preterm infants born between 28 and 32 weeks of gestation. The infants were placed on hammocks within the incubator. One group had motorized hammocks providing horizontal and vertical oscillations at a constant rate; a second had free-slung hammocks which moved in response to the infants’ own body movement; while those in the third ex-
Experimental group were placed in stationary hammocks and the control group of subjects received normal care. The size of the sample (five in each group) precluded useful analysis, but some indication of benefit was suggested by Neal (1975). While positive benefits of the use of hammocks to provide vestibular stimulation have not been demonstrated adequately, this form of postural support has been found to have no adverse effect on VLBW infants (Bottos et al. 1985).

The combination of aural stimulation in the form of a simulated heartbeat with vestibular activation provided by an oscillating water bed, has not been found to demonstrate additional effects (Barnard 1973, Barnard and Bee 1983, Kramer and Pierpoint 1976). Significant differences in weight gain, head circumference and biparietal skull diameter were reported by Kramer and Pierpoint (1976) in infants exposed to these dual forms of stimulation. An increase in periods of quiet sleep and developmental maturity was found by Barnard (1973) using similar stimuli. Since these differences were very like those previously reported for the use of the water bed alone, it is difficult to suggest that the aural stimulus augmented the intervention.

Investigations of the value of auditory stimulation alone have produced equivocal results. One attempt by Malloy (1979) to compare the effect of a taperecording of a mother’s voice with one of a classical lullaby provided no useful information. The study appeared to have been well planned, but the first measure, at discharge, yielded no usable data, and the BSID (Bayley 1969) administered at nine months of age showed no significant difference between the mean performance of the stimulated and the non-stimulated group. Earlier studies by Katz (1971) and Segal (1972) both examined the influence of daily exposure to a taperecording of the maternal voice. The results reported by Segal (1972) demonstrated that exposure to the auditory stimulus increased the rate of change of the cardiac response to other aural stimulation when measured at 36 weeks of postconceptual age in the experimental group. Based upon this finding, Segal (1972) suggested that the provision of supplementary auditory stimulation to preterm born infants resulted in a greater degree of adaptive responsiveness at the equivalent of 36 weeks of gestational age. Katz (1971) also found that infants exposed to the auditory stimulus showed more mature development of the central nervous system on reaching 36 weeks of gestational age than control infants.

Multimodal stimulation programmes based on a Piagetian model of development also have proven popular. Such stimulation has been evaluated by Brown et al. (1980) in a nursery based programme for preterm infants of socially disadvantaged mothers. The 41 infants fitted the low birth weight description (ie weighed 2000 grams or less at birth) and were randomly assigned among three experimental groups. A control group of a further 26 infants was included also but these subjects were not randomly assigned. Infants in the experimental groups received visual, auditory, kinesthetic and tactile stimulation administered either by nursing staff, by the infant’s mother or by both, while routine nursery care was provided for the infants in the control group.

Weight gain and the NBAS (Bayley 1969) at discharge from hospital, the Home Observation for the Measurement of the Environment (HOME, Caldwell and Bradley 1979) at nine months and the BSID (Bayley 1969) at twelve months of age were recorded. No significant short or long term effects of the stimulation were found for any of the dependent variables.

Superior performance as a result of a multimodal programme of stimulation administered in hospital has been reported by Leib et al. (1980). Fourteen infants made up the experimental group and 14 subsequently born infants formed a control group. All weighed between 1200 and 1800 grams at birth and had no abnormalities. The programme was presented in two forms and administered by the nursing staff. During the period the infants spent in an isoloite, a brightly coloured mobile toy was placed in the isoloite and during gavage feedings each infant was subjected to soothing and stroking of the exteriors, trunk and face. When the infants graduated to an open crib, the mobile toy was hung at eye level and the ‘en face’ position was employed during feeding and combined with stroking, rocking and singing. Infants in the experimental group demonstrated superior performance on the interactive items of the NBAS (Brazelton 1973) at discharge and, at six months, a higher, psychomotor development index (PDI) and mental development index (MDI) on the BSID (Bayley 1969). However, the non-random assignment and possible experimenter bias could have contributed to the observed benefits.

Apart from the efforts to influence sensory motor performance directly, Widmayer and Field (1981) have emphasised the contribution which parent education may play in enhancing subsequent developmental status and parent-infant interactions. Widmayer and Field (1981) invited mothers of infants assigned to an experimental group to be present during the administration of the NBAS (Brazelton 1973) prior to discharge. These investigators then carried out repeated assessment of the experimental and control group infants at one, four and twelve months of age. The opportunity to observe the routine pre discharge testing and significant effects. This was made evident by the subsequent superior motor performance of the infants and the increased amount of face-to-face parent-infant interactions of the experimental subjects and their mothers recorded at the follow-up assessments. Widmayer and Field (1981) concluded that the early exposure of the mother to the range of capabilities of the infant (as revealed in the course of evaluation observed) significantly raised the mother’s expectations of the infant’s responses and affected post-discharge parent-infant interactions in a positive manner.

Physiotherapy Programmes

A variety of programmes of physiotherapy intervention during the period of hospitalization have been described, but few conclusions concerning their efficacy can be drawn from the published reports. Campbell (1974), in a programme for preterm and term born infants with
neurological dysfunction, included facilitation of sucking as an exploratory and adaptive as well as alimentary response, visual stimulation to promote fixation, auditory discrimination, prehension through palmar stimulation and intersensory integration through activities which combined various aspects of the programme.

Other examples such as the Good Start Programme from the Texas Children’s Hospital described by Desmond et al (1980) and those outlined by Anderson and Auster-Liebhaber (1984), Murphy (1984) and Sweeney (1985), provide some of the details of the scope of physiotherapy intervention and follow-up programmes intended to assist preterm infants and their families. While developmental measures usually are repeated throughout the preschool years for the infants serviced by such programmes, no attempt to measure the benefits of the services offered have been reported.

Campbell (1986), Fetters (1986) and Wilhelm (1984) have all discussed the objectives which nursery centered physiotherapy programmes for preterm born infants should address. Both Campbell (1986) and Fetters (1986) have identified a number of models upon which the intervention may be based. Reports of evaluation of these models are beginning to provide valuable information to physiotherapists. The immediate influence of intervention in the nursery on the motor behaviours displayed by preterm infants has been described by Pelletier et al (1985) while Sweeney (1983) has discussed the physiological cost to the preterm infant of the use of hydrotherapy. Both of these reports indicated that motor performance was improved in the short term.

Conclusions
In summary, it seems that preterm born infants do derive benefit from stimulation during the period of their hospitalization. The form of stimulation which has been shown most consistently to be of benefit is one in which movement is provided, activating either the vestibular or kinesthetic sensory modalities. When offered in isolation auditory stimulation using the maternal voice is useful but other forms of sensory stimulation appear to produce equivocal outcomes. When combined with movement of the passive infant the influence of both auditory and tactile stimuli have been shown to be enhanced.

Intervention in the Post Discharge Period
Less interest has been displayed in the provision of long-term programmes, operating in the period following discharge. This is not surprising considering the cost of providing services to the population within the widespread community. The interventions which have been reported in the post discharge period have been designed by a number of different health professionals.

Scarr-Salapatek (1973) described an early regime of this nature. This author employed a multimodal stimulation programme incorporating visual, tactile and kinesthetic stimuli administered both in hospital and through weekly visits to the infant’s home until the child was one year of age. Infants in the experimental group were reported to show enhanced developmental status at both four weeks and twelve months of age when compared with the control group. However, relatively few of the control group were available for the twelve month evaluation which limited the author’s ability to draw firm conclusions from the study results.

More recent reports suggest that interest is growing in the need to understand the value of continuing stimulation programmes. Despite the lack of evidence to support the use of tactile stimulation derived from nursery based programmes, it has been suggested to be beneficial when applied in the post discharge period (Rice 1979). The Rice Infant Sensormotor Stimulation treatment is described as consisting of ten minutes of massage in a cephalocaudal distribution with five minutes of subsequent holding and cuddling of the infant (Rice 1979). For evaluative purposes, the programme was tested by its author on 30 infants of less than 37 weeks gestation who were randomly assigned to either an experimental or a control group. Mothers of infants in the experimental group were trained in the administration of the programme prior to the discharge of their infants from hospital. Mothers of the control group received only normal discharge information. Stimulation was offered to the experimental infants for 15 minutes four times per day for 30 days beginning on the day after discharge from hospital. During the experimental period, public health nurses visited the homes of the experimental groups regularly, adding a dimension of concern which was not offered to the control group thereby confounding the report of a positive outcome. At four months the experimental group showed improved weight gain, earlier acquisition of the Landau and labyrinthise righting reactions on the head and superior performance on the PDI and MDI of the BSID (Bayley 1969).

Intervention over a longer duration based upon a Piagetian model has been reported by Resnick et al (1987). These authors have reported on a prospective two year follow-up study of the influence of a multidisciplinary, parent centred, intervention programme on the developmental status of preterm infants at 12 and 24 months of age. Two hundred and fifty-five infants born between 1979 and 1981 were assigned to either an intervention or a control group on an alternate basis at 24 hours after birth. Mean birth weight for the intervention group was 1411 grams and gestational age was 31.5 weeks. The control group did not differ significantly on these parameters. The control group (131 subjects) received routine in-nursery care and participated in routine follow-up assessment. Infants in the intervention group (124 subjects) were nursed on a water mattress, provided with visual stimulation and were given twice daily developmental activity sessions, each of 20 minutes duration. Parents were instructed in the application of the most appropriate activities for their own children and were required to administer the programme with further assistance provided as appropriate. The sessions consisted of full body massage, passive movements,
prefeeding oral stimulation, playing of tape recordings of a human heartbeat and classical music and procedures described as ‘bonding interactions’. All activities were offered when the infants were in a suitably responsive state. Prior to discharge, activities for the early home management of the stimulation programme were identified and taught to the mother in the same way as before.

Following discharge each child in the intervention programme received bimonthly visits from an early childhood development specialist who provided information about the use of appropriate items from a sequential developmental curriculum described as consisting of 400 items. These items were in seven developmental categories: personal-social, visual, auditory, language, memory, perceptual motor and physical. Counselling, referral or similar needs of the family were met also by the home visitor. No method of controlling for the absence of this repeated home based service to the nonexperimental families was reported.

An independent routine follow-up using the PDI and MDI of the BSID (Bayley 1969) was carried out on all subjects who returned for assessment at one and two years of adjusted age. At the one year assessment, there were 67 subjects remaining in the intervention group and 66 in the control group. At the two year visit 27 and 26 subjects were assessed in the respective groups. A significant difference in the incidence of developmental delay in the two groups was noted. The control group was found to have a significantly greater percentage of infants who displayed developmental delay (18% versus 4% at 12 months and 26% versus 4% at 24 months). A beneficial effect which appeared to increase as the children grew older was reported in this study. The increased developmental advantage of the experimental group over the control group with increasing age is a phenomenon which has been reported elsewhere (Ramey et al. 1984). It is difficult, however, to assess the extent to which the additional interest shown in the experimental group and not offered to the control group may have been responsible for the more advantageous outcomes.

**Physiotherapy Programmes**

Support for the findings of Resnick *et al* (1987) has come from the results of another study based upon similar principles (O'Reilly *et al* 1986). One hundred and two VLBW infants were randomly assigned to one of two experimental groups or to a control group. The first group received an individualised intervention programme which was taught to the parents. Parents were encouraged to work with their infants on a daily basis during the period of hospitalization and follow-up. Support was provided by twice monthly contacts with the research team. The second group received an equal amount of interest from the researchers, but it was of a generalised nature and no activity programme was instigated. The control group received routine care.

Stepwise regression analysis using an *a priori* selected predictors of outcome demonstrated that at nine months of adjusted age 13% of the variability of the PDI and 31% of the variability of the MDI of the BSID (Bayley 1969) could be attributed to group membership. While more of the variability could be accounted for by other factors (ethnic grouping, 30% of the MDI, composite post natal factors score, 30% of the PDI), this statistically significant finding does indicate that if the experimental design includes a control for the effect of interest by the research team, the intervention programme can be demonstrated to have an important influence on the infant’s subsequent developmental status.

Programmes based on neurodevelopmental therapy treatment models of intervention have been less successful. Goodman *et al* (1985) reported the outcome of a monthly physiotherapy visit, combined with a home programme carried out by parents. Criteria for admission to the study included birth weight of less than 1700 grams and gestation of less than 34 weeks. The subject population consisted of 80 infants who were admitted to the study at three months of adjusted age. Infants were classified as ‘normal’ or ‘at risk’ on the basis of a neurodevelopmental score determined by the authors. Those making up the normal group had a neurodevelopmental score of less than four and those in the high risk group scored between four and twelve. The infants, whether classed as normal or at risk, were then alternately assigned to either an intervention or a nonintervention subgroup. Apart from the preponderance of families of lower SES in the at risk group, the groups did not differ significantly in other respects.

Unfortunately, the study was confounded from the beginning because infants with scores of greater than ten on the neurodevelopmental test were all assigned to the high risk intervention group. They were considered to be neurologically impaired and therefore could not be denied the intervention. Additionally, as the study progressed, any infant not in an intervention group found to have shown deterioration subsequently, was reassigned. The authors do not make it clear, but it appears that the results of such infants were not included in the analysis of the outcome measures.

Treatment consisted of neurodevelopmental therapy (NDT) as described by B. Bobath (1967) and K. Bobath (1980) and was administered in monthly 45 minute sessions in a hospital outpatient setting by therapists certified in the use of this form of treatment. Parents were given a home programme also, consisting of a daily formal treatment session and the inclusion of desirable movement patterns for daily activities. The treatment showed no significant effect for either the normal or at risk groups on repeated neurodevelopmental assessment (at six, nine and twelve months of age) or the Developmental Quotient or any of the subscale scores of the Griffiths’ Mental Development Scale (GMDS, Griffiths 1954). From the results reported it must be concluded that an approach to intervention centred upon regular, hospital based, NDT treatment supported by a parent administered daily home treatment programme, was not successful in improving performance on either a measure of neurological development or a measure of general developmental
status. This negative finding could be related to the age at which the intervention was commenced, to the treatment model upon which the intervention was based or to the dependent variables selected to measure the effect of the programme.

A similar treatment model adopted by Piper et al. (1986) was equally unsuccessful in improving performance in preterm infants on a number of dependent variables measuring developmental outcome. One hundred and thirty-four infants in two risk categories (VLBW, or all infants who had experienced birth asphyxia, seizures or central nervous system dysfunction with one abnormal electroencephalographic recording) were recruited from two NICUs in Montreal. Balanced, block randomization, achieved by categorizing the subjects according to three birth weight categories (<750 grams, 750 to 1500 grams and >1500 grams) and optimal neurological status as described by Prechtl (1977), were used to assign the subjects to one of two groups. The groups received either a standard follow-up programme consisting of routine developmental assessments or physiotherapy based upon the NDT model proposed by the Bobaths (Bobath B 1967, Bobath K 1980).

Treatment was commenced as the infants reached term and continued until twelve months of adjusted age. Infants were seen weekly for one hour by a physiotherapist certified in the practice of NDT during the first three months of the programme and once every two weeks thereafter. Half the treatment session was devoted to intervention by the therapist and the other half to parent instruction in the implementation of a programme to be carried out at home on a daily basis. To aid compliance, parents were asked to record the daily use of the programme in a notebook provided for the purpose.

The success of the programme was measured by several different tests administered at twelve months of adjusted age. Results of 115 infants were available for final analysis. No significant difference between the experimental and control group was found on any of the 25 pre and peri natal variables recorded on admission to the study. The analysis of variance statistic was employed to assess the role of the physical therapy programme on the prevention or minimization of handicap. Neither the three-way (Group × Optimality Score × Birth Weight) nor either of the two-way (Group × Optimality Score, Group × Birth Weight) interactions were significant and none of the main effects yielded significant results.

Unfortunately, the interpretation of the results is somewhat difficult. While the report includes the mean values of all the dependent variables for the experimental and control groups, standard deviations are omitted and the magnitude of the within group variability is therefore unknown. This variability is likely to be quite large since the twelve month neurological assessment indicates that ten of the subjects (seven in the experimental group and three in the control group) were frankly abnormal. Also, since some infants in the control group who demonstrated developmental delay appear to have received physical therapy on referral to other agencies, it is not entirely correct to claim that physiotherapy intervention was confined to the experimental group. It can only be said that the NDT programme as offered in the study was not experienced by the control group.

The study is of major significance to the debate over whether NDT as a physiotherapy treatment technique contributes to improved developmental performance. However, the failure of the study to yield a significant Birth Weight × Groups Interaction demonstrates only that an intervention programme which is essentially hospital centred and based upon a model designed for the treatment of movement dysfunction will be unsuccessful in improving developmental outcome in VLBW infants. It may highlight also the need to examine more closely the methods employed to assess developmental status when offering a programme intended to enhance sensory motor performance.

Conclusions

In addition to suggesting that intervention programmes which include stimulation of the kinesthetic and/or vestibular sensory systems provided by movement are of positive benefit to the preterm born infant, it is possible to identify other factors which contribute to the usefulness of such regimes. Success appears to be more likely if the programme is parent centred, that is if it involves the parents in the administration of the stimulation, and if the regime is based on a model which is not treatment related. This last point is important as physiotherapists working in NICUs are becoming increasingly involved in offering prophylactic treatment intervention for infants considered to be at high risk for later movement dysfunction.

Research Problems in Intervention Studies

Other critical reviews of intervention studies which report the effects of programmes directed towards enhancing the developmental status of preterm born infants have been presented by Campbell (1983), Cornell and Gottfried (1976), Field (1980), Masi (1979), Ross (1984) and Schaef er et al. (1980). Criticism of early intervention programmes is common and, it would appear, not unjustified. Cornell and Gottfried (1976) were the first to question the value of the wide range of stimulation programmes being advocated for neonatal intensive care management. In addition to the problems of research design and methodology identified by these authors, the lack of knowledge of the course of development in the preterm infant and the conflicting views of the needs of the infant and its family were considered by Cornell and Gottfried (1976) to be factors which contributed to the often contradictory reports being generated. An evaluation of nursery intervention programmes for preterm infants in which tactile or kinesthetic stimulation was employed was undertaken by Ross (1984). Of those identified, few were considered by this author to meet the criteria for valid research and absence of adequate rationale or consistent parameters for the implementation of the programmes described, was a notable feature.

Simeonsson et al (1982) reviewed 27 research reports of a range of intervention programmes. They divided the ex-
Early Intervention Programmes

samples cited into four groups based on the degree of rigour of the methodology employed. The studies could be classed as retrospective, prospective with no control group; prospective with control group but lacking random assignment and prospective with random assignment to the intervention versus no intervention conditions. While the review does not deal specifically with intervention programmes for the preterm infant, the finding that few met the requirements of basic research design and appropriate statistical analyses is relevant to the present discussion.

In an attempt to understand the contrary viewpoints being expressed by studies which described intervention for preterm infants, Field (1980) examined the type of stimulation presented in each of the programmes reviewed. She concluded that the variation in results reported could be explained in part by the differences between the studies related to the selection of subjects, the form of intervention offered and the manner in which the additional stimulation was presented.

Despite the conflicting information being reported, Masi (1979) concluded that in general, stimulation programmes were beneficial. However, Masi (1979) suggested that there were many unanswered questions which should be addressed. These included identifying both the most appropriate point for introduction of a stimulation programme and the dependent variables which were most useful in examining the influence of the intervention offered. Schaefer et al (1980) came to conclusions similar to those described by Masi (1979). Unfortunately, Schaefer et al (1980) failed to comment on the methodological weakness of some of the studies reviewed, which detracts somewhat from their findings.

Campbell (1983) reported that improved cognitive development and increased weight gain were the most frequently described results of intervention programmes with preterm infants. Few reports of improved motor performance were noted by Campbell (1983) despite the fact that this area of behaviour was the one cited by Masi (1979) as being most enhanced by intervention.

Summary

Very preterm, VLBW infants who survive must overcome many medical and psychosocial problems which have the potential to exert negative influences on their subsequent developmental status. Efforts to minimise the adverse effects which appear to be a consequence of preterm birth have led health professionals in a number of differing fields to promote the value of specific intervention programmes. Despite the fact that the stimulation presented in such programmes has been energetically pursued, the value of the programmes promoted has not been established.

It is evident from the intervention programmes described in this review, that the problems of insufficient subject numbers, lack of controls, absence of random assignment and inappropriate dependent variables are repeated in many of the studies reported. In addition, those health professionals who develop stimulation programmes, appear to do so without adequate consideration of the objectives of such management and therefore pay insufficient attention to the components included in the programme.

That a planned programme of intervention is of long term value in assisting preterm infants to enhance their deficient motor development still remains to be satisfactorily established. However, there are indications that programmes which educate parents about the abilities of their infants and encourage them to promote those abilities may be helpful (O’Reilly et al 1986, Resnick et al 1987, Widmayer and Field 1981). Additionally, it appears that the provision of stimulation which incorporated activation of the kinesthetic and vestibular sensory receptors through movement is of benefit in the early weeks of life (Korner et al 1983, Kramer et al 1975, Field et al 1986).

What is not evident is whether a stimulation programme must be instigated during the period of hospitalization to be successful, or whether it can be offered following discharge and be equally successful. Whether it must then be continued until the infant is older is also unclear. A further question unanswered by the investigations reported here relates to the long term benefits of early intervention. Does the effort expended during the first months of extrauterine life make a difference to the child’s developmental status in the pre-school and early school years? The number of unanswered questions raised in reviewing the value of intervention programmes for preterm infants, indicates the need for further and more rigorous investigation of this area of early infant development. However, it is apparent that some forms of intervention are of value. Physiotherapists should be guided therefore by these findings when planning programmes for the very preterm, VLBW infant.

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