Special Article

Interventions for children with neurodevelopmental delay

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Objectives. To review studies in the scientific literature of five physical interventions commonly recommended for children with neurodevelopmental delay.

Design. A literature search for and a review of the results of controlled and other studies conducted in the course of the last 25 years.

Setting. Institute of Child Health, University of Cape Town.

Subjects. Patterning; neurodevelopmental therapy; sensory integrative therapy; optometric visual training; auditory integration therapy.

Outcome measures. Findings and conclusions drawn in the studies reviewed.

Results. Controlled studies fail to provide evidence to support claims made for the five interventions examined.

Conclusions. In the absence of scientific evidence for efficacy patterning, neurodevelopmental therapy, sensory integrative therapy, optometric visual training and auditory integrative therapy cannot be recommended for children with neurodevelopmental delay.

S Afr Med J 1997; **87:** 1680-1684.

In South Africa today an array of interventions is on offer for the child with neurodevelopmental delay. The doctor who believes in evidence-based treatment and who wants the best for his or her patients may find it difficult to select what is appropriate and cost-effective from the therapies available. In the private sector the situation is complicated by the readiness with which some therapists advocate and commence therapy before there has been any consultation with a medical practitioner. This practice can lead to months of inappropriate and ineffective treatment before ever the child undergoes comprehensive diagnostic assessment.

This paper is an attempt to review dispassionately the scientific literature pertaining to five physical interventions commonly recommended for children with real or alleged neurodevelopmental delay.

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Patterning

This intervention was developed in the 1950s in Philadelphia by Glen Doman, a physiotherapist, and Carl Delacato, a psychologist.[1] They felt it was essential for every child to follow stage by stage the standard developmental pathway. Any deviation, such as omission of the crawling stage, would have dire consequences such as inordinate clumsiness, mixed dominance or a specific learning disability. They correlated developmental milestones with seven levels of brainstem and cortical function and postulated that a block at any one of these levels precludes development of functions controlled by higher levels. This is caused by an interruption in the sensory feedback essential for the development of complex motor function. Doman and Delacato reasoned that if this sensory input could be supplied by repetitive passive movements of the limbs and trunk (a process they called 'patterning'), cortical learning would take place and in time the individual would become able to perform the movements spontaneously. Other forms of sensory stimulation such as bright torchlight shone into the eyes and repetitive loud noises are recommended to supplement the movement sequences. On the frontispiece of his book, Doman[2] claims effectiveness for a wide spectrum of disabilities.

Freeman[3] has written a scholarly criticism of patterning and two studies have shown no advantage for patterning over control groups.[4,5] The American Academy of Pediatrics and the American Academy for Cerebral Palsy[6,7] long ago expressed strong reservations about this form of intervention. However, it is still being offered in South Africa by an organisation calling itself St Briavels (L Shackleton — personal communication, 1996). Very high fees are charged and major demands are made on parents and family in order to sustain the programme. Improvements in function, if any, are no greater than those observed with the passage of time in handicapped children treated along less aggressive lines. For these reasons it would seem that doctors should actively discourage parents from this form of therapy.

Neurodevelopmental therapy

NDT, as it is commonly called, was developed in the 1940s and 1950s by Dr Karel and Mrs Berta Bobath.[8] Their empirical approach was based on a concept of hierarchical reflex levels within the nervous system. Brain lesions cause loss of the normal inhibition of primitive reflexes and this leads to the abnormalities in tone, altered postural reactions and impaired movement patterns found in children with cerebral palsy. Therapy that entailed various postural manoeuvres aimed to inhibit primitive reflexes, reduce increased tone and replace abnormal movement patterns with more normal ones. Subsequent recognition of the role of central feed forward motor programmes has led to modifications in NDT techniques. It has been accepted that postural adjustments are task- or context-dependent and can be learned and elicited in an anticipatory manner. This understanding has led to much greater emphasis on the facilitation of motor patterns with practical value and less concern about the quality of individual movements.

Controlled studies of NDT are difficult to devise for a number of reasons, not least of which is the fact that no two subjects with motor delay are identical. It is also well recognised that many untreated handicapped children make motor progress at a rate comparable to that of treated children. Functional improvement in response to the same treatment varies widely from one individual to the next and it is difficult to establish a common endpoint or goal that is appropriate to all subjects. Many of the earlier studies therefore fall short of acceptable criteria for scientific research or can be severely criticised on methodological grounds.

Published studies provide little support for NDT. Four controlled trials[9-12] have failed to show any improvement in treated children compared with controls. Reviews and meta-analyses of 26 other studies do not provide evidence of any advantage over conventional management.[13-15]

On the other hand, Irwin-Carrruthers[16] has reported attainment of major motor milestones significantly earlier than controls in a group of children treated early. Subjects in a study by Ottenbacher *et al.*[17] performed 'slightly better' than the control comparison subjects who did not receive NDT. Mayo[18] and Bower and McLellan[19] both found enhanced progress when the therapy was administered as an intensive programme and Kluzik *et al.*[20] demonstrated enhanced arm function in an ingenious study using infra-red movement markers.

These few studies notwithstanding, a review of the literature lends support to Ferry's[21] 1981 assertion that there is no valid scientific evidence that these programmes alter neurological development in high-risk or neurologically handicapped patients. Similarly Graves,[22] in a thoughtful recent review, came to the conclusion that claims for functional improvements resulting from therapy methods could not be substantiated.

Sensory integrative therapy

Sensory integrative therapy (SIT) was first described by an American occupational therapist, Jean Ayres.[23] She postulated that delay in the acquisition of complex motor patterns and learning disability were expressions of a central failure to process sensory input from proprioceptive and kinaesthetic receptors. She saw dysfunction of the vestibular organs as central to the problem and devised tests to demonstrate this dysfunction and therapy programmes to remedy it. She claimed that these programmes 'enhance the organisation of brain mechanisms and neural integration'.

In one of her books[24] she tells parents that 'since the brain is something that doctors study in medical school, you might assume that physicians know about sensory integrative disorders. However, most paediatricians, family doctors and psychiatrists will not see a sensory integrative problem even when it exists.' This statement places a question-mark over the scientific validity of her work and subsequently, in separate controlled studies, Brown[25] and Polatajko[26] both showed that vestibular function does not differ from normal controls in children with specific learning disabilities. Nevertheless SIT is still practised with uncritical dedication by occupational therapists in South Africa.

Assessments of function according to Ayres' system are so rigid that few preschool children receive an entirely normal rating. In a reappraisal of eight papers published by Ayres between 1965 and 1987, Cummins[27] has shown that not one of her named criteria reliably distinguished between children with a learning disability and non-disabled children. He concluded that no validity could be demonstrated either for the diagnostic procedures or the remedial programmes derived from her work.

Statistically and scientifically acceptable outcome studies of SIT, as with NDT, are difficult to devise as it is always hard to distinguish improvement brought about by therapy from what can be expected as a result of normal maturation. Many of the studies cited by Ayres and others in support of SIT have major methodological flaws and there is a disturbing tendency in published papers to blame inconclusive or negative results on inappropriate measurement and goals rather than any lack of efficacy of the treatment itself.

In 1982 Ottenbacher[28] performed a meta-analysis of eight studies of SIT and concluded that empirical support existed for this form of therapy. In 1989 Cabay *et al.*[29] reported 'weak positive trends' in an uncontrolled study of preschoolers and in 1993 De Gangi[30] found that structured sensory motor therapy was more useful than child-centred therapy in promoting a number of gross motor skills.

These findings have not been confirmed by other published work. In 1980 Sellick and Over[31] reported a matched control study in which children with cerebral palsy were subjected to sessions of vestibular stimulation over a 4-week period. Measurements of motor function 1 week and 18 weeks after treatment showed the same gains in both treated and control groups. In a study not free of methodological flaws, Densem *et al.*[32] report no subsequent significant differences in groups exposed to SIT, physical education and no treatment. Polatajko *et al.*[33] found no difference after 6 months between children subjected to SIT and children subjected to a programme of perceptual motor training. Wilson *et al.*[34] found no difference after 6 or 12 months between a group of children subjected to SIT and a group subjected to individual tutoring. In this study an unexpected finding was that tutoring was as effective as SIT at improving motor function. In a control study by Humphries *et al.*,[35] a perceptual motor group improved more than the SIT group on two tests. In all the other outcomes tested the treated groups did no better than untreated controls. In 1995 Polatajko *et al.*[36] reported a study in which children with developmental co-ordination disorder (DCD) were subjected either to SIT or a programme called process-orientated treatment. A third group with DCD received no treatment and served as controls. At post-treatment and follow-up assessments children subjected to either of the interventions did not perform any differently from those subjected to no treatment.

The studies cited demonstrate why there is major controversy about this form of therapy and why uncritical acceptance and application for any perceived shortcoming from manual function in 4-year-olds to scholastic problems at primary school cannot be condoned.

Optometric visual training

Optometric visual training for children with reading difficulty was first mooted in the 1950s and early 1960s in the USA. It is claimed that reading difficulty in the early grades may be due to lack of smooth eye pursuit, jerky saccadic movements and minor degrees of heterophoria. These deficiencies will be overcome by a course of eye exercises together with balance beam training and the performance of tasks aimed at promoting visual perception and eye/hand co-ordination. This regimen is often coupled with the prescription of low-dioptre reading glasses. Although visual training has been formally denounced a number of times by the American Academy of Ophthalmology, the American Association for Pediatric Ophthalmology and the American Academy of Pediatrics (1972, 1984, 1992),[37-39] it is still vigorously promoted by certain optometrists in South Africa.

Pavlidis[40] found that dyslexics have erratic eye movements while reading and carrying out other saccadic eye movement tasks. Poynter *et al.*[41] demonstrated a multivariate correlation between 4 oculomotor functions and reading comprehension and Evans *et al.*[42] found a higher incidence of phoria (deviation of eye axis) in learning-disabled students. On the other hand studies by Adler-Grindberg and Stark,[43] Brown *et al.*,[44,45] Stanley *et al.*,[46] Olson *et al.*[47] and Polatajko[48] have all failed to demonstrate any difference in the eye movements of learning-disabled children and age-matched normal controls. Hall and Wick[49] assessed eleven different ocular functions in scholars drawn from grades 1 to 6. There was no significant multivariate correlation between ocular functions and the students' reading ability.

It is difficult to find acceptable studies which demonstrate improved reading ability after vision therapy. Solon[50] claimed that 3 teenagers with convergence and accommodation problems showed gain in reading comprehension after vision therapy. Wold *et al.*[51] reported enhancement of reading ability. Other studies[52-54] cannot be accepted as they fail to fulfil basic methodological criteria for scientific research. Yet other studies cited in support of vision therapy show improved convergence,[55] accommodation[56] and binocular fusion,[57] but do not demonstrate improved reading ability.

On the other hand, in 21 of 25 studies reviewed by Hammill[58] the authors concluded that no concomitant improvement in reading ability could be expected as a result of systematic visual motor training. Hammill felt that his findings affirmed the view that reading ability and visual perception are unrelated functions. The same conclusion was reached by Metzger and Werner[59] in a more recent review of the literature on visual training for reading disability. A study by Heath *et al.*[60] showed no improvement in reading ability after eye exercises and a number of other studies have confirmed the ineffectiveness of perceptual training in promoting reading ability.

Reading is an acquired cortical activity peculiar to the human race. Children become able to read as they learn to recognise written symbols for letters and later words and to recode these into spoken words. This process is a function of memory which some take longer to acquire than others and it is not influenced by vision, given reasonable functional acuity. The jerky eye movements exhibited by many children with reading difficulty are an expression of visual to verbal recoding deficit and are not the cause of the reading problem. Delay in immediate recognition of letters and words results in rapid rescanning until comprehension is achieved. Similar rescanning is observed in adults reading unfamiliar texts of a highly technical nature. Slow readers do not differ from average readers in perceptual recognition and reproduction tasks. Their problem arises when the symbol is a grapheme, and may be likened to the predicament of an English-speaking adult never schooled in Greek, Hebrew or Russian when confronted by a written work in one of these languages. He sees the text perfectly but cannot read a word!

Dyslexia is a syndrome of deficiencies in the cortical storage and retrieval of linguistic information.[61] This is supported by neuro-anatomical,[62] imaging,[63] EEG[64] and radio-isotope studies[65] that demonstrate cortical abnormalities in dyslexic subjects.

Two further studies have relevance. In 1987 Beauchamp and Kosmorsky[66] reviewed optometric vision training and found that controlled evidence for treatment efficacy was 'contradictory, conceptually flawed and scant'. In the same year Vellutino,[67] writing in *Scientific American*, said that the most efficacious therapy for reading difficulty is early one-to-one remedial tutoring with a balanced reading programme using both whole word and phonemic approaches to reading.

Auditory integration therapy

This intervention was developed by a French ear specialist, Berard.[68] It entails the earphone presentation of music that has been processed by an instrument called an audiokinetron. Berard maintains that negative behaviours associated with autism are the consequence of hypersensitivity to certain sound frequencies. This is demonstrated by fluctuations in auditory threshold as shown on the audiogram. The audiokinetron severely disrupts the rhythm and loudness of music by switching between low- and high-pass filtering at an irregular rate. Berard feels that this rests the hypersensitive hair cells and so eliminates the audiogram peaks. A course of treatment consists of 20 half-hour sessions extending over 2 weeks.

The intervention was publicised in the USA in a book called *The Sound of a Miracle*.[69] It was written by Annabel Stehli, who claimed that her 13-year-old daughter had been cured of autism by a course of AIT. This predictably caused a stir among parents of autistic children and certain therapists were not slow to exploit the situation. In no time improvements were claimed in: quantity and quality of receptive and expressive language, auditory processing, behaviour, concentration, persistence, social functioning, initiative and independence in daily living. These gains were reported not only in autistic children but in a wide spectrum of others with parent-perceived shortcomings.

Objective assessments of the effects of AIT are few. In a controlled study of autistic children carried out by Rimland and Edelson[70] some improvement in behaviour was reported. Most benefit occurred in lowest functioning individuals. No relationship could be demonstrated between pretreatment sound sensitivity and subsequent behaviour improvement. In a well-structured study by Rankovic *et al.*[71] it was shown

that during therapy, the average noise level at the ear-drum is 110 decibels. This is sufficient to damage the organ of Corti, and reported decreases in sound sensitivity after therapy may be a result of this rather than any more central effect. Only 27% of the parents of autistic children polled by Monville and Nelson[72] responded to a questionnaire on improvements seen in their offspring following AIT. This calls findings into question and suggests a lack of post-treatment enthusiasm for the intervention.

With its very questionable theoretical background, reported benefits over an unbelievably wide spectrum and lack of support from controlled studies, I do not think we should consider this intervention for any of our patients or take seriously those who promote it in South Africa.

Conclusions

Personal experience and an extensive literature review suggest that the interventions examined are all controversial and that paediatricians should advise against patterning, vision therapy and AIT. What of NDT and SIT? Physiotherapists and occupational therapists have a central position in the team approach to children with physical handicap and neurodevelopmental delay. Studies have shown that their roles as motivators, facilitators and informal counsellors are valued more by parents than their roles as providers of specific therapeutic techniques.[73,74] Wright and Nicholson[9] have suggested that it is the physiotherapist's personality and approach to her patients, rather than what she does, which is to their advantage. It is therefore suggested that paediatricians should promote the team approach to children with physical handicap and neurodevelopmental delay and should encourage therapists to concentrate on the facilitation of specific goal-directed motor patterns of direct practical value to the child in terms of locomotion, self-care skills, scholastic function and recreation.[33,75,76]

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Accepted 9 Jan 1997.