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The Right to Move
Assessing Neuromotor Readiness for Learning
Why physical development in the early years supports educational success

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SUMMARY

This chapter examines how neuromotor maturity can influence educational achievement. It explains how motor skills develop in the first year(s) of life and why movement opportunity is essential for the development of neuromotor skills throughout childhood. It summarises research carried out in schools in the United Kingdom, Germany and Hungary between 2002 and 2011, which has assessed the neuromotor skills of children in mainstream and special schools to investigate possible links between immature motor skills and educational under-achievement. The same research introduced a developmental movement programme into schools and monitored changes in neuromotor status, educational outcomes and behaviour.

The results suggest that one of the fundamental rights of children in an increasingly technological world is the right to space, opportunity and experience of free movement in the early years, to ensure healthy physical and mental development.

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Introduction

"Learning is not all in the mind but is also a physical activity"[1]. One of the first tasks a young child needs to master is physical control of her body in space, with movement experience acting as both the challenge and the teacher. Throughout life movement acts as the primary medium through which information derived from the senses is integrated, and knowledge of the world is expressed. Even thought and perception are an internalised simulation of action[2]. When we imagine, think and dream, the "images" that we see in the mind's eye spring from the experience of movement through space. Coherent perception depends on synchrony in the *timing* of messages received by the different sensory systems transmission to the brain. Time is movement between two points in space[3]. A child's motor abilities are therefore essential tools for learning, and motor skills at different stages in development provide a reflection of maturity in the functioning of the central nervous system – the relationship between the brain and body – which provides the foundation for learning.

The child's brain is not the same as an adult brain. Different regions of the cerebral cortex, the largest structure of the forebrain which contains the higher brain centres controlling intellectual, sensory and motor functions, mature at different rates. The first area to mature is the motor area, followed by the sensory area, with association areas being the last to mature, continuing growth into the twenties or thirties[4]. The higher problems of thinking, planning and problem solving performed by the frontal lobes, take years to develop[5].

At birth, connections to the superficial layer of the cortex are only tenuously formed. The neonate is equipped with a series of survival responses to various environmental stimuli which enable him to breathe, to "root" or search for the breast if the side of his face is touched, to suckle and to grasp if something is placed in the palm of his hand or pressure is applied to the soles of his feet. He also has a series of reflexes which evoke responses to change in position. These innate reflex responses are mediated at the lowest level of the brain – the brainstem – but as connections to higher centres in the brain strengthen during the first weeks, months and years of life, the functional direction[i] and organised control of movement proceeds from the lowest (brainstem) to the highest level of the central nervous system (cortex). "The process of corticalization is characterised by the emergence of behaviours organised at sequentially higher levels in the central nervous system with lower levels being recruited into the service of higher functions as maturation takes place"[6].

Children's motor development is dependent primarily on overall physical maturation, especially skeletal and neuro-muscular development combined with physical interaction with the environment. Children need opportunity for exercise and practise, not only to develop strength but also control and dexterity. Infants have a natural repertoire of rhythmic motor activities which involve kicking, waving, punching, stretching, rocking and twisting and these rhythmic activities or primary motor vocabulary provide an important transition from uncoordinated activity to coordinated motor behaviour[7], but they occur in the context of *opportunity*. Opportunity requires the space and time to experience physical activity in all sorts of different ways, from the gross motor movements involved in rolling, walking, running and jumping to the fine motor skills needed for feeding and writing"[8].

there is also a growing body of evidence which indicates that an increasing number of children are entering formal education lacking the physical skills, which are necessary to support all aspects of formal education. These children are at risk of under-achieving and/or developing various social or behavioural problems unless this immaturity is recognised and addressed.

Underachievement – a barrier to well-being

There can be many reasons why a child fails to attain competence in literacy, numeracy and grapho-motor[ii] skills. Some of these problems are already addressed by services within education systems and initiatives to support development in the early years. However, there is also a growing body of evidence which indicates that an increasing number of children are entering formal education lacking the physical skills, which are necessary to support all aspects of formal education. These children are at risk of under-achieving and/or developing various social or behavioural problems unless this immaturity is recognised and addressed.

A report published by Ofsted (the United Kingdom's school inspection body) in 2010[9] stated there was a significant percentage of children whose mastery of basic skills continued to fall below expected levels at the end of primary education with children from poorer backgrounds being at a particular disadvantage (Goodman and Gregg 2010)[10]. Despite initiatives established under the Early Years Foundation Stage document (EYFS)[11] in 2008, intended to monitor children's progress more closely in the early years, the "targets" set by the EYFS tended to focus on *performance outcomes* rather than assessing and nurturing children's *physical "readiness"* for formal education[iii].

Readiness for school requires much more than a child simply reaching the chronological age required for school entry. To perform well in an educational environment, a child needs to be able to: sit still; pay attention; use a writing instrument, and to control a series of eye movements, which are necessary to follow a line of print without the eyes "jumping" or losing their place on the page. These are physical abilities, which are linked to the development and maturation of motor skills and postural control. Growth and physical development are as important to education as they are to the field of developmental medicine but have been largely overlooked by the educational system since the phasing out of routine developmental tests for all children in the United Kingdom, which until the 1980s used to be carried out by the school doctor prior to school entry at between 4 to 5 years of age. Findings from other countries suggest that this problem is not confined to the United Kingdom but may be a growing problem in other developed countries.

One method of observing a child's physical development is through the assessment of primitive reflexes, postural reactions, balance and coordination. Every child's brain is designed to follow an orderly, predictable inter-related sequence of development, facilitated through maturation and entrained through interaction with the environment. Aspects of a child's development may be inferred from his or her motor skills. Primitive reflexes and postural reactions provide useful tools in this respect because there are key stages in development when primitive reflexes should be active, suppressed and transformed into mature postural reactions. Reflex status viewed in the context of a child's chronological age can therefore provide a reflection of maturity in the functioning of the individual child's central nervous system.

The normally developing infant, born at full term (40 weeks gestation), is equipped with a series of primitive reflexes to help it survive the first weeks of life before connections to higher centres in the brain have developed. Primitive reflexes are stereotyped reactions to specific stimuli, which allow no leeway for variation or choice of action. Well recognised examples of primitive reflexes include the grasp reflex in the hands and the rooting and suck reflexes.

Fig. 1 Grasping reflex in a neonate

Fig. 2 Rooting reflex in neonate

During the first six months of life, as the central nervous system (CNS) matures, primitive reflexes are inhibited and, in some cases, transformed into more mature postural reactions. Retention of primitive reflexes beyond the first year of life provide markers of immaturity in the functioning of the CNS[iv].

The findings suggest that neuro-motor immaturity is a factor in a significant percentage of children in mainstream schools in several countries. The incidence appears to be highest amongst children already identified as having special needs.

What is the extent of the problem and what type of children does it affect?

In 1996 The Institute for Neuro-Physiological Psychology (INPP) in Chester, U.K developed two short screening tests designed to be used by teachers to observe the physical development of children from 4 -7 years of age and from 7 years of age upwards, together with a physical intervention programme. Since 2004, a number of schools in different parts of the world have carried out formal evaluations using both the INPP screening test and intervention programme. The findings suggest that neuro-motor immaturity is a factor in a significant percentage of children in mainstream schools in several countries. The incidence appears to be highest amongst children already identified as having special needs.

The study carried out Northern Ireland (2004) aimed:

1. To determine whether residual reflexes were a predictor of poor educational progress.
2. To evaluate the effectiveness of the INPP Developmental Movement programme by measuring the educational progress associated with undertaking the prescribed exercises.
3. The INPP Developmental Movement Programme comprises a series of exercises based on movements normally made by the developing child in the first year of life, at the time when primitive reflexes are inhibited and postural reactions develop. The exercises are carried out as a class based activity in school for 10 minutes every day, over the course of one academic year, under the direction of a teacher who has attended a training day in the use of the programme. This general programme is based on a more specific clinical programme used at INPP since the 1970s with individual children, following more extensive assessment of their neuromotor skills.
4. Both the individual and school INPP programmes are based on Blythe's theory of replication. Blythe asserted that, "the innate mechanistic processes involved in the inhibition, modification and transformation of the basis reflexes are observable, and more importantly are replicable at any age, to assist in the rehabilitation of neurological impairment"[12], and that it is possible to give the brain a second chance to utilise the inhibitory movement patterns which should have been integrated at an earlier stage in development. Repetition of these movement patterns has an inhibitory effect on abnormal reflexes, securing the basis for balance, posture and coordination and improving the neuromotor skills needed to support learning.

Country	Type of School	Number of Participants	Age Range (years)	% of sample with evidence of Residual primitive reflexes
Northern Ireland (UK)	6 mainstream primary schools	672	4–5; 8–9	48% 35%
Northumberland	4 primary schools; area of social deprivation	25 52	4–6; 7–8	40% 88%
Germany	Primary School	164	7-8	50-60%
	Special class for children with speech problems		7-8	100%
	Steiner Waldorf School*	28		72%
Hungary	**Special** class for children with **language problems** in primary school (Bp II district)	20	7-8	100%
	Special class for children in Music School (Bp IX district)	21	7-8	100%
	Special class for socially disadvantaged children (Northern Hungary)	82	7-8	100%
	Special class (boarding school) for socially disadvantaged children (Southern Hungary)	33	14-15	93%
Total		**1064**		

Table 1. Incidence of children with traces of abnormal reflexes in selected schools in the United Kingdom, Germany and Hungary 2004-2011.

To investigate these connections measures of retained reflexes, balance, educational ability and concentration/co-ordination were made in a controlled study of P5 (8-9 years old) children in seven Northern Ireland primary schools at the start (September 2003) and end (June 2004) of the school year. In each school one P5 class undertook the exercises and the other did not. Two P2 (4-5 years old) classes in each school also participated in the research. None of the P2 classes undertook the exercises, and the extent to which the presence of retained reflexes at the start of the school year can predict educational progress at the end of the year was assessed 35% of children in the 4-5 year old group had elevated levels of retained reflexes at the first assessment (elevated levels of primitive reflexes in a school-aged child provide evidence of neuro-motor immaturity). Elevated levels of retained reflexes were correlated with poor educational achievement at baseline in the younger group. 48% of children in the 8-9 year old group had elevated levels of retained reflexes. 15% (49) of the sample had a reading age below their chronological age. Of these, 28 also had elevated levels of retained reflexes[13].

The Northumberland project (2006) was undertaken with a group of 187 children from 4 mainstream primary schools in an area of social deprivation. Analysed data is available for 72 children in the sample. The figures showed a slightly different trend from the Northern Ireland study, with children in the older group having a considerably higher incidence of abnormal reflexes (88%) than children in the younger group (40%)[14 15].

Unpublished results from 4 mainstream primary schools in Germany (2010) found that in a sample of 164 children aged 7-8 years, 50 - 60% of the sample showed traces of residual primitive reflexes. In a special class for children with speech problems, 100% of the sample had evidence of residual primitive reflexes. This may be significant because in addition to being a language skill, which involves auditory processing, speech is also a *motor* skill, recruiting motor centres which control the movements of the lips, tongue, swallowing and breathing. Some of the same centres in the brain are also responsible for controlling fine movements of the fingers. Empirical evidence obtained from more than a thousand children assessed at the Institute for Neuro-Physiological Psychology (INPP) over a number of years has consistently shown that children who have difficulty with dysdiadochokinesia (rapid alternate movements) in the fingers also have a history of either delayed speech or have required speech therapy in the past.

While it has long been recognised that children with speech problems are at increased risk of experiencing difficulties with reading, writing and spelling, this has often been explained on the basis of the underlying language and auditory processing problems. These empirical findings suggest that there may also be a motor component affecting the fine motor skills involved in speech and writing.

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In a smaller sample of 28 children aged 7-8 years in a Steiner Waldorf School in Germany, 72% of the sample had traces of elevated infant reflexes of which 22% had very strong signs of infant reflexes and 50% had moderate signs. **The teacher commented that,** *"These are especially strong figures which do not correspond with the general situation at the Waldorf School. However, in the last two years I have been involved at that school in testing children for neuro-motor maturity before starting school and have found that there is a clear trend of lesser and lesser maturity*[16].

In Hungary (2011), 156 children were assessed for the presence of residual primitive reflexes. All subjects were children who had been identified as having special needs. Similar to the figures from Germany, the percentage of children with abnormal reflexes was higher amongst children in Hungary identified as having special needs than in samples of children in mainstream classes in other countries.

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The findings available to date suggest that neuro-motor immaturity may be present in a significant percentage of children in primary schools with the incidence being higher amongst children already identified as having a special need. This raises a number of questions:

- Why do primitive reflexes persist in some children?
- What is the impact of residual primitive reflexes on education?
- Is this a growing trend?
- Are social changes contributing to the problem?
- Can anything be done to improve residual reflexes as markers of neuro-motor immaturity?
- Should neuro-motor maturity be assessed as a matter of routine?
- Is there anything that can be done in the early years to prevent an increase in the problem?

Before attempting to answer these questions, it is necessary to describe and explain the role of primitive reflexes in development in more detail.

What is a primitive reflex?

A reflex is an automatic instinctive unlearned reaction to a stimulus, which is carried out without volition or conscious control with the same stimulus always evoking the same stereotyped response. Well recognised examples of reflexes include the automatic constriction of the pupils of the eye in strong light or the knee jerk in response to tapping of the knee.

Primitive reflexes are a particular group of reflexes which are only present in the first few months of life and diminish as the central nervous system of the infant matures. Primitive reflexes develop during life in the womb, are active for the first few months after birth and then gradually recede as connections to higher centres in the brain develop. Examples of primitive reflexes include reflexes for sucking, grasping and responding to change of position.

Primitive reflexes are significant, because the presence or absence of primitive reflexes at key stages in development, provide acknowledged signposts of maturity in the functioning of the central nervous system. While doctors, midwives and health visitors are familiar with assessment of the primitive reflexes at birth and tests for primitive reflexes are repeated at developmental check-ups in the first six months of post natal life, if development appears to be progressing normally at six months then these tests are not repeated in the pre-school or school aged child.

Primitive reflexes never entirely disappear but become inhibited as "higher" centres in the brain mature in the first months of life. Primitive reflexes can remain active if there has been damage to higher centres in early life such as cerebral palsy or may be released if there is accident or damage to higher brain centres in later life, for example after a stroke, head injury or in degenerative diseases of the central nervous system such as multiple sclerosis or Alzheimer's disease. According to medical theory, primitive reflexes should not remain active in the general population beyond 6 months of age and if elicited beyond this age are usually considered to be indicative of underlying pathology.

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However, there is an increasing body of evidence which suggests that *traces* of primitive reflexes (residual reflexes) can remain active in the general population in the absence of identified pathology (McPhillips et al.2000[17], Goddard Blythe 2000[18] , McPhillips and Sheehy 2004[19], Taylor et al. 2004[20], Goddard Blythe 2005[21], McPhillips and Jordan-Black 2007[22]). Residual presence of primitive reflexes in children above the age of 6 months can therefore provide indications of neuro-motor immaturity, which, if present, can act as a barrier to learning.

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Assessment of primitive reflexes beyond the first 6 months of life provides the clinician or educator with tools with which to:

1. Identify signs of neuro-motor immaturity (Identification)
2. Assess the type and level of intervention which is appropriate for the child (Intervention/Remediation)
3. Measure change in reflex status before and after intervention (Evaluation)

What is the significance of neuro-motor maturity to education?

A longitudinal study which is tracking the progress of nearly fifteen thousand children who were born in the United Kingdom between 2000 and 2001 (The Millenium Cohort Study) released findings in February 2010, which showed that children who failed at nine months to reach four key milestones in gross motor development relating to sitting unaided, crawling, standing and taking their first steps were found to be five points behind on average cognitive ability tests taken at five years of age compared to those who passed the milestones. "Delay in gross and fine motor development in a child's first year, was significantly associated with cognitive development and behavioural adjustment at five" (Schoon I, 2010).

What effects can immature reflexes have on development and learning?

Abnormal primitive and postural reflexes in the older child can affect functioning in many different ways:

- Control of posture when standing, sitting or moving
- Balance
- Ability to sit still
- Coordination and motor skills
- Control of eye movements needed for reading.
- Hand-eye coordination needed for writing and drawing
- Spatial skills and organisation
- Concentration
- Emotional functioning
- Behaviour including impulse control

Children with partially retained primitive reflexes tend to reach developmental milestones at approximately the normal time and are often overlooked during standard medical screening tests carried out in the first year. Signs of difficulty only begin to emerge when they start formal schooling

Children with *partially* retained primitive reflexes tend to reach developmental milestones at approximately the normal time and are often overlooked during standard medical screening tests carried out in the first year. Signs of difficulty only begin to emerge when they start formal schooling when "symptoms" such as difficulty in learning to read or write, general restlessness or immature behaviour appear, but do not point directly to an underlying physical dysfunction.

Some children may go on to be diagnosed as having a specific learning difficulty such as dyslexia, developmental coordination disorder (formerly dyspraxia) or attention deficit disorder; others are able to use their intelligence to compensate for the underlying difficulties but compensation comes at the price of under-achieving in the classroom; a third group start to develop a variety of behavioural or emotional problems, which are the product of frustration, poorly developed self-regulatory skills and inability to match performance to intelligence, resulting in under-achievement in the classroom, on the sports field or problems with social integration. One such child was described by his parents as, "being 10 years old on the outside but only 3 years old on the inside".

What is the impact of residual primitive reflexes on education?

Each reflex has been identified as playing a part in specific aspects of learning and behaviour (Goddard 1996[25] , Goddard Blythe 2008[26]). When neuro-motor immaturity is present in a school aged child, several reflexes (a cluster) are usually involved before symptoms start to show up in the classroom. A few examples of individual reflexes and their effects are described below:

1. **The Asymmetrical Tonic Neck Reflex (ATNR)**
   The Asymmetrical Tonic Neck Reflex (ATNR) is elicited by rotation of the head to one side, which results in extension of the arm, hand and leg on the side to which the head is turned and flexion of the opposite (occipital) limbs (Fig. 3)

Fig. 3
The ATNR in the first month of life

If the ATNR remains active in a school-aged child, it can interfere with control of upright balance, because turning of the head causes the arm and leg on one side of the body to straighten while the opposite limbs bend, upsetting control of balance. It can also interfere with control of the arm and hand when the head is turned to one side, ability to cross the midline of the body (Goddard 1995)[27] affecting left-right integration (DeMyer 1980[28], Holt 1991[29]), control of the hand when writing (Blythe & McGlown, 1979[30]), and the visual skills necessary for reading such as visual tracking (Goddard 1995[31], Bein-Wierzbinski 2001[32]).

2. **The Symmetrical Tonic Neck Reflex (STNR)**
While the ATNR influences muscle tone on either side of the body, the Symmetrical Tonic Neck Reflex (STNR), affects functioning and integration of the upper and lower sections of the body. The STNR emerges at approximately 5-8 months of age, as the infant is getting ready to push up on to hands and knees to crawl. Flexion of the head (bending the head forwards) causes the arms to bend and the legs to straighten (Fig 4); conversely, extension of the head results in straightening of the arms and bending of the legs (Fig. 5).

Fig. 4 STNR in flexion

Fig. 5 STNR in extension

(Fig 4 and 5 from The Genius of Natural Childhood. 2011. Hawthorn Press. Stroud)

If the STNR has not been suppressed in the school-aged child it can affect posture when sitting or standing, the ability to sit still, and the muscle tone and coordination needed for activities such as learning to swim and do forward rolls. Other researchers have found a link between retention of the STNR and Attention Deficit Hyperactivity Disorder (ADHD) (O'Dell and Cook 1996[33]) and problems with speed and accuracy of copying (Blythe and McGlown 1979[34]).

3. **Head Righting Reflexes (postural reactions)**
Retention of primitive reflexes can also affect the development of subsequent postural reactions, such as the head-righting reflexes, which are essential for the maintenance of proper head alignment in relation to body position, upright head and body posture and control of eye movements (De Quiros and Schrager 1978[35], Kohen-Raz 1996[36]). Head righting reflexes operate in response to change in body position, automatically correcting the head position to the midline. Not only does this automatic righting reaction facilitate good maintenance of balance but head position also provides the reference point from which centres involved in the control of eye movements take their cue. If the head position is misaligned is, then control of eye movements will also be compromised. This can affect reading, writing, copying and operations in space.

4. **The Palmar Grasp Reflex**
While the ATNR, STNR and head righting reflexes are all examples of reflexes which operate through the balance mechanism, reflexes which respond to touch can also have an impact on learning outcomes. The palmar reflex is one example of this. If the palm of a new born baby's hand is touched, the thumb closes inwards and the fingers close on top forming a grasp or fist grip, which in theory, is strong enough from which to suspend the entire weight of the neonate for a few seconds (Fig 6).

Fig. 6 The infant palmar grasp reflex

Retention of the palmar reflex beyond the first few months of life can interfere with the development of the thumb and finger opposition movements, which are necessary to form a "pincer" grip and to use each finger independently. This can interfere with the ability to form a good writing grip (Fig. 7) and can sometimes be linked to a history of speech problems. Speech can be affected by this simple reflex because the same motor centres in the brain responsible for the control of fine finger movements are also involved in motor movements of the lips, tongue and cheek muscles required for the motor aspects of speech.

Fig. 7 Writing grip characteristic of a child with a residual palmar reflex

How are reflexes integrated in the course of normal development?

In the normal developing child, the transition from primitive reflex to postural reactions takes place as a result of two processes working together: Firstly, maturation within the central nervous system and secondly, interaction with the physical world.

In the first six months of life the formation and strengthening of connections between lower and higher centres in the brain take place at a rapid rate, enabling the cortex to exercise increased executive control over the planning of purposeful movement and flexibility of response to sensory stimuli. At the same time, muscle tone and control of movement also increase, rendering primitive, automatic and stereotyped reflex responses redundant. These interactive processes require physical experience, repetition and practice to develop. Reflex integration is therefore a gradual process which takes place in the context of normal development in the first year(s) of life in conjunction with movement experience.

Primitive reflexes also have a *role* in early development. Some reflexes such as the ATNR and spinal Galant reflex (a reaction to touch or pressure applied in a downward direction to one side of the spine, eliciting flexion of the hip on the same side) are thought to assist in the birth process; others such as the rooting and suck reflexes enable a child to feed at birth, while the Moro reflex (an instant reaction to sudden or unexpected sensory stimuli) acts as the infant's arousal and fight/flight reaction to aversive stimuli. Reflexes also provide a ready-made repertoire of unconscious reactions to sensory stimuli before connections to higher centres in the brain have developed, ensuring that the infant responds to certain stimuli. (Details of other reflexes and their effects on functioning can

be found in literature listed in the bibliography at the end of this chapter.) This is important because *movement is the primary medium through which sensory integration takes place*.

Early feeding reflexes provide an example of this. If the area around the side of the mouth is gently stroked shortly after birth, the new born baby will turn its head and using touch, will try to nuzzle, search or "root" for the breast (a similar type of action to a cat rubbing itself against its owner's legs when it wants to be fed). Initially, it is the sense of touch and smell which leads the new born to the breast, and when the roof of the baby's mouth makes contact with the breast, another reflex will automatically stimulate sucking movements. If breast feeding is successfully established, within only a few weeks, *sight* of the breast will be sufficient to stimulate sucking movements. In other words, touch, smell and motor action lead into visual recognition.

A different example can be seen during integration of the Symmetrical Tonic Neck Reflex. Initially the reflex helps the infant to get up off the ground from prone to a four point kneeling position ready to crawl. However, as long as the STNR persists, movement of the head up or down will cause one end of the body to collapse, preventing the infant from being able to crawl. Most babies go through a brief phase of "rocking" on hands and knees (Fig. 8), which helps to integrate the reflex sufficiently so that a few days later he or she is able to put its head up and maintain control of the upper and lower sections of the body while moving. The reflex has helped one stage of development, but spontaneous movement is necessary to facilitate the next. The action of crawling on hands and knees is also important as it coordinates use of balance, upper and lower body, left and right sides and the visual system all at the same time. The hand-eye coordination that takes place during crawling is at the same relative visual distance that a child will use a few years later to read and write and may be an important stage in training later visual-motor integration.

Fig. 8 Rocking on hands and knees prior to learning to crawl

Why do primitive reflexes persist in some children?

The traditional view still prevails that retention of primitive reflexes beyond the first six months of life is a sign of pathology. However, as discussed earlier, more subtle signs of residual primitive reflexes can and do exist in the general population in the absence of a medical diagnosis. A developmental screening questionnaire, devised at The Institute for Neuro-Physiological Psychology (INPP), which has been in use for more than 30 years, has consistently shown that if there is a *cluster* of factors (more than 7) in early development such as medical problems during pregnancy or the birth process and delay in achieving milestones during the first 12 months of post natal life, a child is more likely to have retained immature reflexes which can potentially affect later learning outcomes (Goddard Blythe and Hyland 1998[37]).

Are social changes contributing to the problem?

Empirical evidence from clinical observation in the last 10 years suggests that these underlying physical factors may be compounded by lack of environmental opportunity in the early years needed to develop physical skills. Such factors would include over-use of baby equipment resulting in less physical contact with parents and carers, lack of free unrestricted movement (floor play), particularly "tummy time" in the first year of life; busy parents who have less time to spend with their children together with over-reliance on electronic devices rather than one-to-one physical interaction to keep babies and children entertained; While these observations need more evidence to support them, there is a risk that as technologies advance, new generations of parents, carers and teachers become increasingly *un*aware of the importance of physical experience in the early years to lay the physical foundations, which support later learning and that children are being deprived for social and cultural reasons of the very physical experiences which prepare the body and the brain for learning and for life.

In many cases immature primitive reflexes and postural reactions can be improved with the use of physical intervention programmes. These programmes can be used with individual children in a clinical setting or with groups or a whole class of children in schools.

Can anything be done to improve neuro-motor immaturity in the older child?

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The INPP Developmental Movement Programme for use in Schools[38] has been evaluated in a number of studies and projects. In Northern Ireland (2004) the intervention programme was evaluated for P5 (Primary Class 5, aged 8 – 9 years) children who had high levels of retained reflexes *and* who were underachieving educationally (the criteria for which the programme was designed), and also for all children, regardless of their reflex or educational scores.

- Children who undertook the exercise programme showed a statistically significant greater decrease in retained reflexes than children who did not undertake the exercises.
- Children who undertook the exercise programme showed a highly significant improvement in balance and co-ordination, and a small but statistically significant increase in a measure of cognitive development over children who did not undertake the exercises.
- No difference was found in reading, handwriting or spelling in children who were already achieving at or near their chronological age, but for children with high levels of retained reflexes and a reading age below their chronological age, those who undertook the exercise programme made greater progress.
- Retained reflexes are correlated with poor cognitive development, poor balance, and teacher assessment of poor concentration/co-ordination in P2 (Primary Class 2 – aged 5 – 6 years) children. Neurological scores and teacher assessment at baseline predicted poorer reading and literacy scores at the end of the study[39].

In Northumberland (2006), where half of the children in the 7-8 year old group took part in the INPP programme and the other half carried out a daily programme of general exercises (Activate programme[v]), children in the INPP group showed a significantly greater decrease in scores for abnormal reflexes than children who participated in the general movement programme, although both groups made progress.

These findings mirrored an earlier study carried out at a school in Derbyshire which had involved a sample of 93 children divided into three groups: Group 1 followed the INPP Developmental Movement Programme for Schools each school day for one academic year: group 2 followed a daily programme of general physical exercises for the same time period; group 3 did not follow a daily exercise programme but continued to participate in all physical education classes provided under the national curriculum. Children who followed a regime of daily exercises made twice as much improvement in measures of reflexes, balance and coordination than children who did not do daily exercise in school, but the gains in the general exercise group were only *half* of those who followed the developmental movement programme every day[40]. These findings suggest that daily exercise of any kind is beneficial, but that daily exercise programmes tailored to the developmental capabilities of the group may be more effective when attempting to remediate specific signs of neuro-motor immaturity.

Other reported findings from teachers in schools where the programme has been used include: improvements in playground behaviour; children are quicker to settle down to lessons following the daily movement sessions; handwriting improves and children report finding it easier to write; improvements in reading; improvements in children's posture, poise, coordination, confidence and consideration for others. In one area where 5 children had been referred to the behavioural support service, at the end of the first term on the programme all children had been removed from the referral list despite no specific behavioural intervention having been introduced[vi].

Should neuro-motor maturity be assessed as a matter of routine?

If findings to date are representative of a growing number of children in the developed world, they suggest that there is a need to return to routine testing of children's physical skills at key stages in development. Such screening tests would enable the trained observer to:

1. Identify signs of immaturity
2. Identify the degree of immaturity and make referrals to the appropriate agencies for more detailed assessment, early diagnosis and intervention if required.
3. Identify children who are under-achieving or at risk of under-achieving as a result of neuro-motor immaturity
4. Implement researched daily physical programmes into the school day to improve neuro-motor functioning.

What else needs to be done?

While more extensive research to determine the true level of neuro-motor immaturity amongst all primary school children is required, based on the findings to date, the following recommendations are offered for consideration:

1. Developmental testing (physical) of all children at the time of school entry and at key stages through education. This should include routine tests for:
   a) neuro-motor maturity
   b) vision
   c) hearing
2. Implementation of effective (researched) daily physical programmes into schools.
3. Flexibility within education systems to:
4. a) allow young children an extended period of time to develop physical skills either before entering formal school, or in the first year(s) at school if required
5. b) take biological age (date of birth in relation to gestational age) into account in relation to time of school entry and year group
6. More emphasis in teacher training on the role of physical development and its impact on learning success – theory, assessment and intervention.
7. Improved awareness and education of parents, and teenagers (parents of the future) of the importance of physical development to support learning. The former could be introduced into sex education classes at school, and the latter into prenatal classes for parents.
8. Improved inter-disciplinary communication and cooperation between the professional domains of Medicine and Education from birth throughout the school years.
9. Improved education of the general public in **what children need** in the early years to develop the physical skills that are necessary to support cognitive learning and social integration.

Human beings are also mammals and have evolved in the context of the physical world. We begin life learning *how* to move and for the remainder of life movement experience will continue to entrain, enhance or impede learning. Competence and confidence in the use of the body develop in the context of interaction with the physical world and social engagement. In ancient Greece, there were two essential branches to education – athletics to learn mastery of the body - and music to develop the mind. When there is congruence in the relationship between the brain and the body, the mind is set free. In the context of an increasingly urbanised and technological world, it is proposed that it should be recognised that it is every child's fundamental right to have the opportunity to move and to develop the physical skills which are needed for learning, for life and for well-being.

[i] *Functional direction in this context describes increasing involvement of higher centres in the brain in the motor planning and control of voluntary movements*

[ii] *Grapho-motor – motor aspects of writing*

[iii] *In 2011the EYFS was reviewed in a report headed by Dame Clare Tickell in which it was recommended that the number of cognitive targets be reduced and a short check be carried out by early years practitioners at two and a half years of age. The results of the developmental check should be inserted into a "red book" which all parents are given as a record of their child's health. While these recommendations are a step in the right direction, they do not guarantee that problems identified at two and a half will be followed up when the child enters school.*

[iv] *If traces (as opposed to the full reflex reaction) are still evident in an older child, they are sometimes described as "residual". INPP uses a 0 – 4 rating scale for assessing the presence of primitive reflexes in the school aged child. A score of 0 is used when there is no evidence of the reflex (no abnormality detected or NAD); a score of 4 is used when the reflex reaction is as strong as in the neonate; a score of 2 or 3 might be described as residual. In the context of this rating scale, a score of >0 may also be described as an "elevated" score.*

[v] *Activate in the Classroom is a general movement programme designed to be age specific and uses progressively staged, repeated patterns of movement with music (Sabin V, 2004). The patterns of movement-to-music programmes take a whole class of pupils through 3-dimensional repetitive movement activities within their personal stand-up space. Each exercise is carried out to music which enables the tempo and rhythm in the movements of the pupils to be varied through changes in the music. The Activate programme is designed for daily use at the beginning of the school day, after registration, for about 10 minutes and for 5 minutes immediately after lunch at the start of the afternoon.Activate movements are used for 2 weeks, then moved up in a step by step sequence through a progressive and developmental 36 week structure. The extra activity extensions provided can be introduced at a speed to suit the class. Every 9th week there is provision for the pupils to create their own programme from their favourites or their own original movement ideas.*

[vi] *Reports written by teachers where the INPP movement programme has been introduced into schools may be found at http://www.inpp.org.uk/school-reports*

[vii] *Goddard Blythe SA, 2005. Releasing educational potential through movement. Child Care in Practice.11/4:415-432.*

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INPP Chester is the international training centre for professionals wishing to access The INPP Method.