**The relation of physical activity to cognitive and academic progress**

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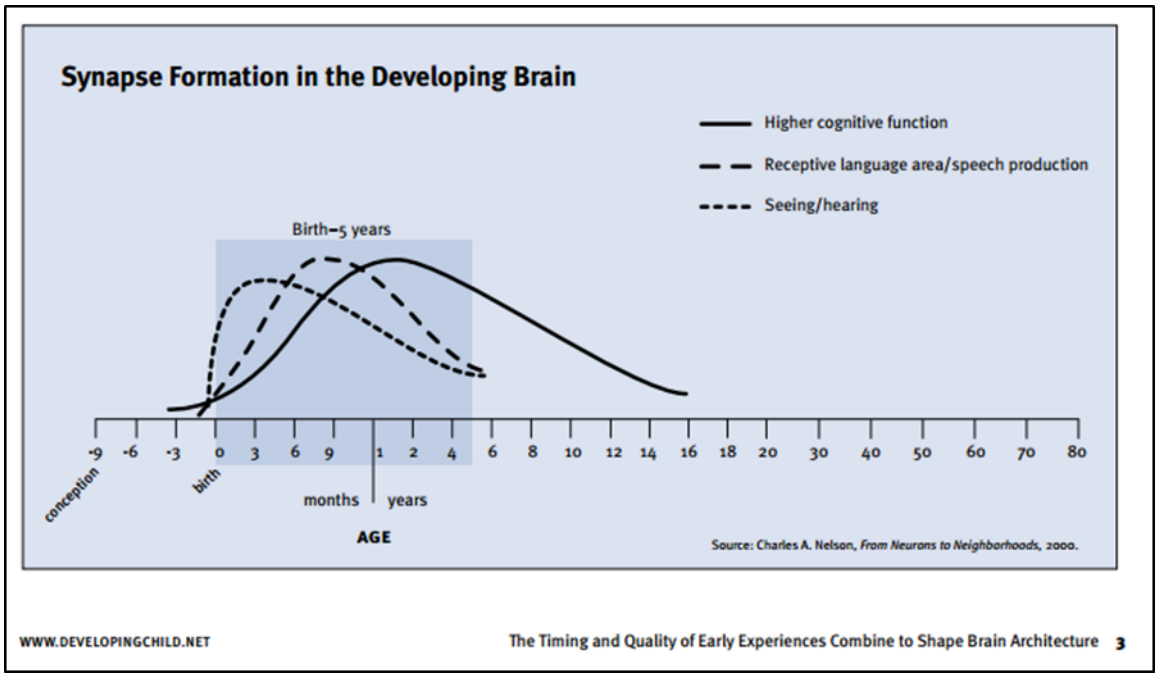
Submitted to the APPG on a Fit and Healthy Childhood

**Human development from conception to 7 years**

Humans are born with large, underdeveloped brains (Fleagle (1); Portman (2) ); This allows for more brain growth to occur postnatally, where the outside world can play a larger role. (Aida Gómez-Robles (3)) Most of this brain-size difference (between humans and other primates) reflects the evolutionary expansion of the association cortex, a group of regions that supports such sophisticated cognitive functions as language, self-awareness, and problem solving. (T.M.Preuss (4) )

Human brains reach approximately 90% of adult volume by age 6 (Reiss et al. (5); Iwasaki et al. (6); Courchesne et al. (7); Kennedy and Dehay (8); Paus et al. (9); Kennedy et al. (10); Stiles et al 2010 (11)).

Structural changes in both the major grey and white matter compartments continue through childhood and adolescence, and these changes in structure parallel changes in functional organization that are also reflected in behaviour. During the early postnatal period, level of connectivity throughout the developing brain far exceeds that of adults (Innocenti and Price (12)). This exuberant connectivity is gradually pruned back via competitive processes that are influenced by the experience of the organism. These early experience dependent processes underlie the well-documented plasticity and capacity for adaptation that is the hallmark of early brain development (Stiles (11)).




(Centre on the Developing Child, Harvard University)

"Until the brain reaches about the age of 7, the brain is primarily a sensory processing machine. This means that it senses things and gets meaning directly from sensations. A young child doesn't have

many abstract thoughts or ideas about things; he is concerned mainly with sensing them and moving his body in relation to those sensations. His adaptive responses are more muscular or motor than mental. Thus the first 7 years of life are called the years of sensorimotor development." (Ayres 2005 (13)).

"A considerable amount of cognitive processes depend on multisensory integration (MSI)" (Dionne-Dostie et al (14)).

MSI has not reached maturity in children younger than eight years old (Gorri et al (15), Nardini et al (16)).

**The key objective of early years' education and physical activities must be to encourage children to achieve good multisensory integration in order to move on to the next stage in their development - this a critical point in human development.**

**These are the foundation skills for numeracy and literacy; if they are not in place they will restrict a person's access to equal opportunities for life.**

That motor sensory development that happens in the first seven years of life in order to achieve MSI includes the following steps:

**Gross Motor skills**:
During the period from birth to 7 years the child moves from helpless on their backs to raising their heads to rolling on to their fronts to being able to sit-up to creeping and crawling and then on to walking on two feet (Shumway-Cook & Woollacott (25)) .

Better motor skills are related to better performance in academic tests (Livesey et al(26) ; Niederer et al(27) ; Nourbakhsh(28) ; Pangelini et al(29) .

Vissier and Franzen(30) identified the relationship between crawling and the development of visual perception, particularly spatial relationships.

Steps in motor integration include:

a. Suppressing primary reflexes and controlling individual limbs;
b. Developing bi-lateral integration of motor skills in four stages: (1) symmetrical bi-lateral integration e.g. clapping hands; (2) reciprocal bi-lateral integration (pedalling a bicycle); asymmetrical bi-lateral integration e.g. one hand holds paper whilst one cuts i.e. one hand leads whilst the other supports; (4) crossing the mid-line to do any task with either hand/foot on both sides of the body.
c. Developing coordinated movement with opposing limbs e.g. skipping with opposing limbs(25)

**Core strength and posture** are needed in order to support the skeleton such that it can move in a coordinated manner; and to create a stable framework to establish good binocular vision, hence visual processing; and also sound processing .

"Children in the younger age groups (4–6 years) may have difficulty in simultaneously performing a postural task and an attentionally demanding cognitive task" (Reilly et al 18))

"Body postural functions precede final central ocular resolution in satisfying the needs of the organism in any visual centred task…we need to teach and monitor postural habits" (Harmon [31])

"Posture should be a key term in voice work" (Rodenburg [32] and Kleinman and Buckoke, [33])

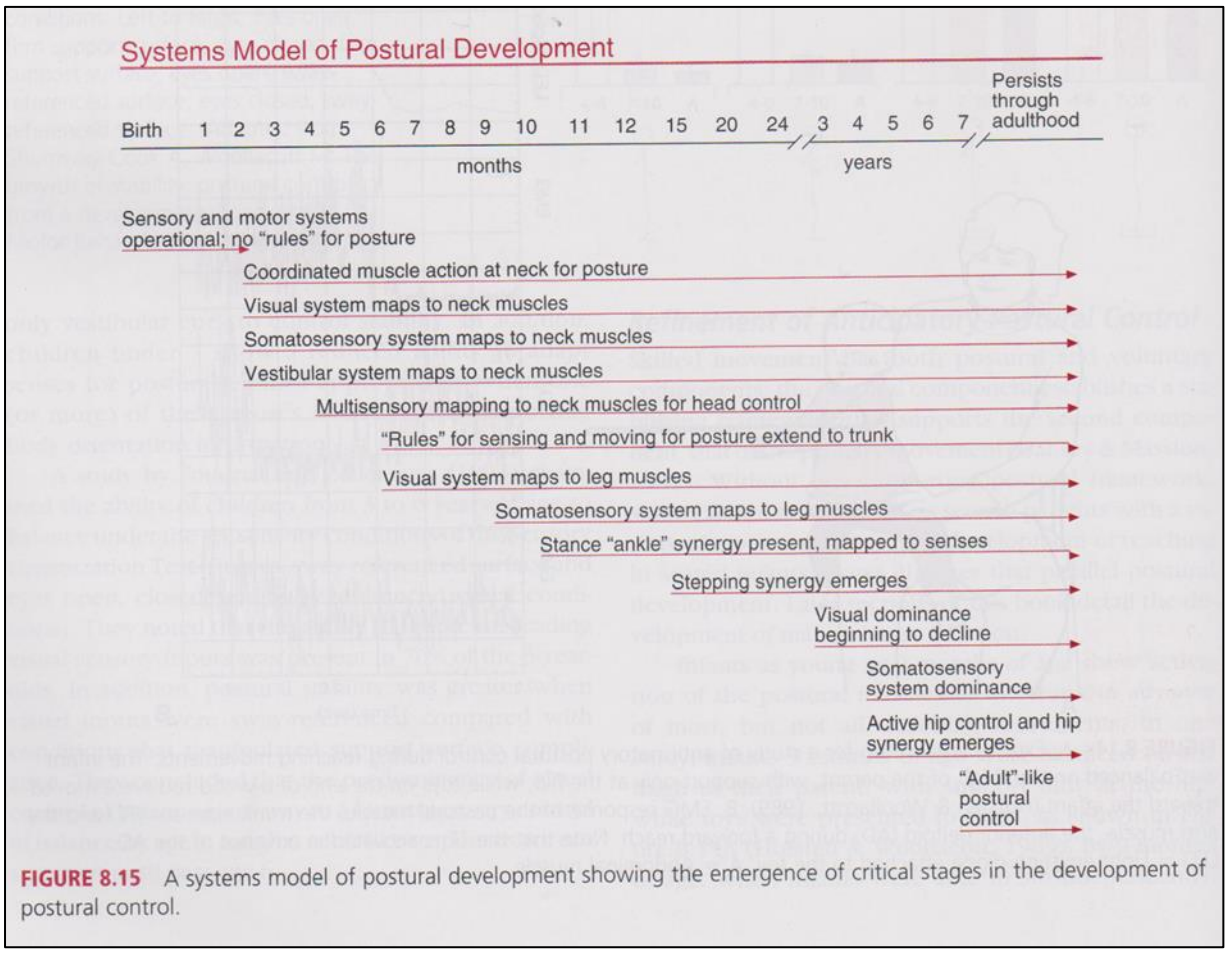



**FIGURE 8.15** A systems model of postural development showing the emergence of critical stages in the development of postural control.

(Shumway & Woollacott[25])

**Fine motor skills:** gaining control of the small muscles in the body including: facial muscles; wrists, hands and fingers; ankles and feet.

The fine motor skills cannot develop properly until the gross motor skills are developed.

Hands and wrists
Complex hand activity involves stereognostic and tactile feedback, muscle, joint, and visual input, and the co-ordination of some 40 muscles (Hyldgaard [21]).

Stability is the prerequisite for prehensile handling of a writing tool. Not even normal sensory acuity can compensate for lack of stability (Napier [22]).

Hand preference is not considered to be established until 6 years of age (Bryden et al [17])

According to Schneck and Henderson [19] 90% of children develop a mature pencil grip by 7 years of age. However, a study by Selin[20] comparing Finnish and US children identified that the early start to

US formal education compared to Finnish formal education meant that US children learnt to grip pencils before their pencil grip maturation process was complete and this blocked their development of a precision grip.

Feet

Humans are born with flat feet and develop arches throughout childhood. Research suggests that the optimal age range for arch development is 4-6 years old and that arches are usually formed completely by age 8. (Lincolnshire NHS(23))

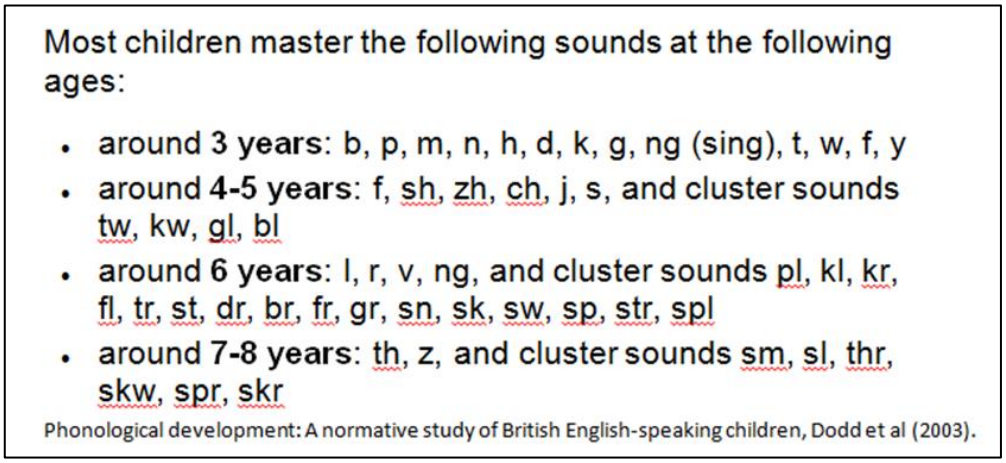
Foot development is linked to postural development and control (25).

**Sound processing skills** i.e. the ability to make sense of sounds for speech and language; and for singing and making music; dancing and rhythmic movement; also for understanding sound patterns, and sequencing (Conway et al(34) ).

Listening therapy impacts positively on motor skills, language and behaviour (Hall et al (35) and Basyk et al (36))

Once a child can process the sounds for their language the child needs to be able to build vocabulary up. Children build vocabulary through repetition, vision and action i.e. children learn best when there is a synchronisity of inputs e.g music and movement; clapping and reciting. (Bahrick and Lickliter, (37))

Speech is the ability to use your lips, tongue and other parts of your mouth to produce sounds: but in order to do that a child must be able to hear and process the individual sounds. “The voice only produces what the ear hears” (Tomatis(38) )




(B.Dodd et al (39))

Development of musical skills

Studies examining within-key compared to out-of-key notes in Western melodies indicate that by 4 or 5 years of age, key membership for Western music is in place (Trehub et al. (42) ; Trainor 2005 ; Corrigall and Trainor (41)) .

Trainor and Trehub [43] ) showed that adults are better able to detect a wrong note in a melody that remains within the key of the melody when the wrong note violates the implied harmony expected at that point, compared to when it is consistent with that harmony. They found that 7-year-olds but not 5-year-olds were adult-like in this ability.

Musicians have enhanced neural encoding of music and of speech (Musacchia, Sams, Skoe, Kraus [44]).

Playing music improves neural speech processing that is important for reading (Kraus, Slater, Thompson, Hornickel, Strait, Nicol and White-Schwoch [45].

Musicians have better auditory attention and memory (Kraus and Chandrasekaran [46])Nat Review of Neuroscience

**Visual processing**

Gessell [47] noted that it was important that a child reached the stage of development where vision was the dominant sense. “Vision is the supreme sense of man…. Seeing is not a separate, independent function. It is profoundly integrated with the total action system of the child, his posture, his manual skills, his motor demeanours, his intelligence, and even his personality traits.”

“The primary biological function of vision is related to determining of space relations and space movements for both orientation and localisation. Secondary is the higher function of abstraction and symbolisation of space and space movement for later facilitation and redirection of movement” (Harmon [48])

“The near point activity of reading is not a natural act. Humans are basically designed for distance viewing. Present estimates are that 30% to 60% of (US) students and adults suffer from a lack of adequate visual coordination skills, poor ocular motility, and accurate visual tracking.” (S.E. Taylor [49].)

“Reading is a highly complex process, involving close interaction among the visual/functional, perceptual, and cognitive functions. A reader’s eyes coordinate as they move along the lines of print in a left to right fashion, pausing three to five times per second to perceive words or parts of words that are continuously added up into thought units, such as phrases or larger syntactical units. The reader then interprets what is read in light of his or her experiential background, associates information, and projects it in terms of association, evaluations, judgements, applications, and conclusions.” (Stanford E.Taylor, [49])

**Eye movements**

**TABLE 2-1 ■ Developmental Trends in Reading Eye Movements**

| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Collimation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fixations (including regressions) per 100 words | 224 | 174 | 155 | 139 | 129 | 120 | 114 | 109 | 105 | 101 | 96 | 94 | 90 |
| Regressions per 100 words | 52 | 40 | 35 | 31 | 28 | 25 | 23 | 21 | 20 | 19 | 18 | 17 | 15 |
| Average span of recognition (in words) | 0.45 | 0.57 | 0.65 | 0.72 | 0.78 | 0.83 | 0.88 | 0.92 | 0.95 | 0.99 | 1.04 | 1.06 | 1.11 |
| Average duration of fixation (in seconds) | 0.33 | 0.30 | 0.28 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.26 | 0.26 | 0.25 | 0.24 |
| Rate with comprehension (in words per minute) | 80 | 115 | 138 | 158 | 173 | 185 | 195 | 204 | 214 | 224 | 237 | 250 | 280 |

From Taylor EA. The fundamental reading skill. Springfield, IL: Charles C Thomas, 1966.

(Schieman & Rouse[50] ) Grade 1 = 6 to 7 years of age; Grade 2 = 7 to 8 years of age and so on.

"There is a dramatic (improvement in the ability to suppress reflexive saccades after 8 years of age" (Schieman & Rouse[50])

**Visual processing development**

Visual-spatial skills are developed in the following age order:

- Under 5 years of age children have incomplete and unsystematic visual search patterns i.e. they have poor form perception skills (Rosinski [51]);
- 6 to 7 years children can correctly identify left and right on themselves;
- 7 to 12 years children develop the ability to correctly identify left and right on objects in space (Laurendeau et al.[52]);
- By 8 years of age most children will have stopped reversing letters (Gibson[53])
- Visual-motor development: a child of 3 years can draw a circle; at 4.5 years a square; at 5 to 5.5 years a triangle; and at 8 years a diamond.(Berry[54] )

**Self-regulating behaviour**

The ability to self-regulate needs to be considered as part of any physical activity programme. It is an important part of self-calming in order to maximise cognitive skills (Watkins 2014[55]). It also helps support children whose lives are less regulated and secure and help minimise the damage from excessive stress[56].

| Age | Normal heart rates range (resting) | Normal respiration rates range (resting) |
|---|---|---|
| Premature | 120-170 | 40 – 70 |
| 0 - 3 months | 100-150 | 35 – 55 |
| 3 – 6 months | 90-120 | 30 – 45 |
| 6 – 12 months | 80-120 | 25 – 40 |
| 1 – 3 years | 70-110 | 20 – 30 |
| 3 – 6 years | 65-110 | 20 – 25 |
| 6 – 12 years | 60-95 | 14 – 22 |
| Over 12 years | 55-85 | 12 – 18 |

**Concluding comments**

In the years from birth to 8 years of age humans develop motor sensory integration. That is the foundation for all higher level skill development.

Learning to 7 or 8 years of age is primarily action and experience based.

Children need the opportunity to use all motor skills and senses every day and reach a point where they are properly integrated. Children and parents need to be supported in this with clear advice on what specific developmental goals children need to achieve and how to do it. All stakeholders need to be focused on these fundamental goals and not to undermine foundation skills development by rushing to complex higher level skills development.

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