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Visual development in children aged 0 to 6 years

Desenvolvimento visual infantil em crianças de 0 a 6 anos de idade

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ABSTRACT | Purposes: This study aimed to present the characteristics of visual development from a clinical viewpoint in infants and preschool children aged 0-6 years who were born at term with no pregnancy or childbirth complications. **Methods**: We conducted a bibliographic review on visual development in infants and preschool children. **Results:** We described visual development in children according to age groups: 0-1 month, 1-3 months, 3-6 months, 6-10 months, 10 months-1 year and 4 months, 1 year and 4 months-2 years, 2-4 years, and 4-6 years. **Conclusion:** Visual responses in infants and preschool children born at term and with normal development were observed to occur in an integrated manner with neuromotor functions in addition to cognitive and psycho-emotional sensory, behavioral, and visual capacity.

Keywords: Vision, ocular; Child; Infant; Visual acuity

RESUMO | Objetivos: Este estudo teve como objetivo apresentar as características do desenvolvimento visual do ponto de vista clínico em bebês e pré-escolares de 0 a 6 anos que nasceram a termo sem complicações na gravidez ou no parto. **Métodos:** Foi realizada uma revisão bibliográfica sobre o desenvolvimento visual em lactentes e pré-escolares. **Resultados:** Descrevemos o desenvolvimento visual em crianças de acordo com as faixas etárias: 0-1 mês, 1 a 3 meses, 3 a 6 meses, 6 a 10 meses, 10 meses a 1 ano e 4 meses, 1 ano e 4 meses a 2 anos, 2 a 4 anos e 4 a 6 anos. **Conclusão:** Observou-se que as respostas visuais em lactentes e pré-escolares nascidos a termo e com desenvolvimento normal ocorrem de forma integrada às funções neuromotoras, além da capacidade sensorial, comportamental e visual cognitiva e psicoemocional.

Descritores: Visão ocular; Criança; Lactente; Acuidade visual

INTRODUCTION

Visual capacity of the central nervous system in humans progressively develops from the birth. The occipital region of the human brain has a specific area for receiving and interpreting images captured by eyes[1]. Optic nerve fiber myelination progresses to completion in the tenth week after birth and consequently rapidly increases the synaptic density of the visual cortex from birth to four months of extrauterine life, reflecting in improved visual perception, fixation, and functional coordination of accompanying motivators of visual stimuli[1,2].

Development of the visual system immediately starts after birth via visual stimuli and interactions with the environment, which concomitantly occur with the child's global development, i.e., neuropsychomotor development, visual-motor coordination, cognitive abilities, and behavioral, environmental, and sociocultural adaptation[2-4]. The anatomical and neurophysiological integrity of this system is essential for the occurrence of the maturation process, which differs with age and is interdependent of genetic, cognitive, and environmental aspects[5,6].

After birth, the visual system undergoes a continuous maturation process involving the eyeball and pathways and neural networks of cortical areas and cortical association areas that integrating different parts. In early life, development of the still immature retinas is accelerated by the fovea and macula, the optical pathways are partially myelinated, and the visual cortex is rudimentary[1,7-9].

Many anatomical changes occur in the visual maturation process, such as the increase in central cone density and elongated outer photoreceptor segments, which develop slowly until age 7 years[3,10], enabling progressive improvement in functional vision and development[11,12].

The light stimuli received by the retina are transmitted to the occipital cortex as specific stimuli formed from the photochemical reactions by the retina after the light capture[1,12,13]. The occipital cortex integrates

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the stimuli received from both eyes into a unique visual perception.

Completing its functional maturity between the ages of 5 and 6 years, this sensorineural mechanism is called binocular fusion. The perceived and unified images are evaluated regarding their form, color, light, and relative location based on the surroundings[9,14], raising awareness of the object's spatial location, i.e., stereopsis[7,11,15].

At 15 days after birth, visual acuity is estimated at 20/400. At this stage, the child shows interest in objects >10 cm in diameter[1,16,17].

Considering normal visual development and cognitive development, children up to age 18 months have similar vision to adults, and a fully developed visual system is perceived until the child becomes 10 years old[10].

Visual development in children

Information about the child's vision can be obtained through objective ophthalmological exams, including electrophysiological tests[10], which evaluate maturation of the cortical visual processes independent of the child's active participation.

Psychophysical tests[13,14,18,19] identify visual responses in children from age zero to 6 years and relate them to normal visual development expected in children born at term without compromising development, with intact visual, sensory, and motor neuron abilities[11,16,20-22]. These tests are standardized with figures, followed with or without the use of recreational objects that encourage visual responses observed through the child's spontaneous behavior[4,10,17].

Normal vision development follows a child's global development in sensorineural nuances; vision maturation is obtained by the visual stimuli provided by both the environment in which the child lives and the child's caregivers. Table 1 shows the maturation of the child's normal visual development, with no developmental compromises, according to each age group.

Table 1. Visual development in children from age zero to 6 years

Age	Visual response
0-1 month (0-28 days)	1st week: Eyes have a dissociated reaction in response to light stimuli. 2nd week: Eyes are directed to light stimuli but cannot hold in this position. 3rd week: There is perception of contrast, with little following. 4th week: There is fixed outline to visual stimuli with larger objects ≥10 cm in diameter. Presents visual following of bright stimuli and close objects at a distance of approximately 40 cm.
1-3 months (1-2 months and 29 days)	Optical nerve fiber myelination; foveal maturation; pupillary reaction; visual response to light focus; eyelid reflection; answer to figures in light and dark contrasts; eye-eye contact; eye movement development; fixation and tracking of human faces; people recognition; facial expression imitation; visual tracking for objects and animals with horizontal preference; look and head movement at 180°: vergency, persecutory reflection, fixation reflex, and fusion reflex; and moving hands toward interesting objects.
3-6 months (3-5 months and 29 days)	Optical nerve favoring the visual cortex synapse, resulting in vision alertness, fixation, and functional coordination for stimuli; eyelid reflection, visual-motor reflection, discriminant perception of colors, plays with the hands in front of the eyes, fixes and follows objects with the eyes, and follows and searches for offered objects; recognizes image when looking in the mirror, recognizes and follows distant objects from approximately 1.20 to 1.80 meters, and answers to smiles; ability to move eyes quickly searching for people, animals, and objects; cervical control favors visual responses, following objects offered in a vertical direction; and begins accommodation reflex, binocular vision, and voluntary control of eye movements.
6-10 months (6-9 months and 29 days)	Depth and tridimensional vision, stereopsis (developed binocular vision and sensitivity to contrasts); gets around avoiding obstacles ahead; searches, handles, and visually explores small objects, watching them closely; and recognizes people, accepting or rejecting them.
10 months-1 year and 4 months (10 months-1 year, 3 months and 29 days)	Optic nerve myelination is complete. Voluntary control of eye movements, focusing and fixing on objects and on people close and of interest. Perception and discrimination of light, dark, and colors. Maintains good eye contact and presents good social interaction with people, animals, and objects.
1 year and 4 months-2 years (1 year, 4 months-1 year, 11 months and 29 days)	Voluntary control of eye movements, focusing and fixing on objects and people at different distances. Perception and discrimination of light, dark, shapes, colors, different sizes of objects, people, and animals. Maintains good eye contact, presents good social interaction with people, animals, objects, and various environments. Recognizes and names people, animals, and familiar objects. Ability to track people, animals, and objects in fast movements. Has insight into similarities and differences. Stands and moves toward people, animals, and objects of interest.
2-4 years (2-3 years, 11 months and 29 days)	Good visual-motor perception and coordination, identifies details in two- and three-dimensional figures and objects. Good body-space sense, understands symbols. Diversity of sensorimotor activities. Ability to follow quick visual stimuli. Full development of visual accommodation. Discrimination and nomination of colors. Notices similarities and differences, figures, and symbols details. Identifies and names figures. Observation: In this period, the child's vision is similar to that of an adult's, except for cognitive proportions and visual experiences.
4-6 years (4-5 years, 11 months and 29 days)	Complete binocular vision. Good notion of figure, depth and background and good understanding of symbols. Observes details of colored pictures, recognizing them as equals, similar, or different. Full capacity of imitating people and animals. Discriminatory vision. Full capacity for spatial perception and location of children and other people, animals, and objects presented at diverse distances. Acquired visual repertory memory.

Considerations

After birth, body cells of the infant are still in full development, forming continuous connections and neural communications. The maturation of the eyes and optic pathways is directly related to the child's visual and neuromotor development[23,24].

The visual system's ability to interpret perceived images is developed following cognitive development together with other skills related to child development, forming and organizing the visual repertory. Stimuli, motivations, and visual experiences are important for maturation of the visual system and its developmental functions[18,25-28].

Each visual function has a specific profile depending on functional potentiality at birth, child development, and the child's visual neuroperception capabilities[6].

Visual system development in children occurs concomitantly with child development. Visual system integrity as well as the neurophysiological structures enable the vision to progress in its functional maturation steps after childbirth[2,23-25].

Objective and psychophysical evaluation of vision must be specific for children and results must be consistent with the child's age[20]. From the beginning of extrauterine development, the child must receive continuous stimuli and visual experiences to develop the optical system in order to present expected visual responses in each age group.

CONCLUSION

Visual responses in infants and preschool children born at term and with normal development occur in an integrated manner to neuromotor functions in addition to cognitive and psycho-emotional sensory and behavioral and visual capacity.

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