ASSESSMENT AND REHABILITATION OF VISION IN INFANTS

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Visual impairment impacts child’s development in a complex way. Therefore, it represents a large problem for a child that also affects the whole family and the community. Timely intervention based on appropriate stimulations can improve child’s visual function and facilitate development in all areas. Early recognition and high-quality assessment of the child with problems in visual functioning is crucial to provide timely intervention. High quality assessment encounters assessment of visual functions, functional vision and other child’s abilities. The aim of this review was to present basic visual functions and functional vision parameters that can be assessed in infants, and the basics of functional vision rehabilitation in infants. The differences in terms visual function and functional vision regarding assessment and rehabilitation of visual problems are described. In description of visual functions the emphasis is on functional problems that can occur as a result of impaired function. Four main areas of functional vision assessment are presented in relation to assessment of an infant. The special emphasis in this review is on the importance of assessing the whole child in all areas of development, and not only visual problems, because the effects of different impairments are mutually interwoven.

INTRODUCTION

Visual impairment is a large and growing socioeconomic problem. Although visual impairment and blindness among children is much less common than among adults, the potential lifespan of a child means that the lifelong impact of such impairment is very large (1). Observational and behavioral research has shown that early development of a child is constrained by impaired vision in a complex way (2-5). Examples include the integration and interpretation of input from the other senses, development of emotional bonding, personality and self-concept, social interactive skills, sound and tactile localization skills, fine motor and locomotor competence, object per- ceptual, and the formation of language and other cognitive concepts (3, 6-10).

This makes visual therapy, in order to encourage visual functioning, a crucial therapy in early life of a child with low-vision.

Much has changed in the last two decades, treatable or preventable disorders, such as cataract and retinopathy of prematurity (ROP) has become a less common cause of low vision in children (1, 11). On the other hand, the prevalence of visual impairment caused by genetic and untreatable neuro-ophthalmological disorders is increasing, as a result of increased survival of preterm and low birth weight children and improved di- agnostic possibilities (1, 11-14). This complex etiology of visual impairment very often causes multiple disabilities in children. As a result of this, all referrals to the most frequent are intellectual disability, motor problems and epilepsy (11, 15). Sometimes it is hard to estimate which impairment influence the function we observe. If a child keeps the head leant on one side, is it because of visual problem (nystagmus, eccentric viewing) or is it because of motor problem (head or posture control)? Therefore, it is sub- stantial to reconsider methods of visual assessment to be sure to measure exact function. We have to be able to disting- uish the impairment that affects certain function, and the way it influences on the specific behaviors.

FUNCTIONAL VISION ASSESSMENT

Terminology related to visual func- tion is different among the various profe- ssions. Under the aspect of visual func- tions, we measure parameters that defi- ne how the eye functions; these include visual acuity, visual field, contrast sen- sitivity, etc. We do this by varying one parameter at a time in a simplified, ar- tificial environment (16-20). They are examined, with few exceptions, for each eye separately, because impairment can exist on only one eye (19). Under the as- pect of functional vision, we must assess how the person functions visually. To do this, we must focus our attention on visu- al skills and abilities. Such tasks always involve multiple parameters, which can vary independently and cannot be sepa- rated (16-20). Assessment of functional vision does not apply only on one eye, because person can function well in visi- on related tasks with remaining vision in only one eye (19).

By assessing only structural changes on eyes it is impossible to indicate how the visual system is really functioning. Therefore, we have to assess visual func- tions of the entire visual system (visual pathways, cerebral visual functions), as well as eyes. Knowing the condition of visual functions and visual fields provide com- plete information about performance of a person, so we have to assess the person’s ability to function in vision related tasks (16). Functional vision assessment invol- ves evaluations of all mentioned func- tions through observation of behaviors, answering questionnaires and solving different visual tasks. It can be done using non-standardized materials and standardized tests while playing with the child. It is performed through asse- ssment of visual functions and observ- ing the child’s ability and the manner of using its vision (20).

We were accustomed to measure, with several tests, what the child sees, but in early intervention, rehabilitation and special education we have to know how the child perceives and interpret his environment and tasks. With the newest scientific findings, combined with ear- lier works we can start asking ourselves why the child sees, as he seems to see? What is the nature of the vision loss (21)? Results of functional vision assessment can give us information concerning remain visual functions and possibilities for vi- sion therapy. This knowledge will guide the rehabilitation professionals in deve- loping rehabilitation plans for the indivi- dual and recommending appropriate low vision devices (22). It can also be used for other purposes, such as prediction of problems in performance that are needed to determine the eligibility for disability benefits (23). Also, a vision rehabilitati- on assessment of visual related skills and abilities are the primary outcome mea- sure for vision rehabilitation outcome study. Therefore, better assessment of func- tional vision is the most urgent (22).

And, if we ask ourselves why the child does see how the sees it can help making the differential diagnosis between possi- ble eye and/or cortical impairment.

ASSESSMENT OF VISUAL FUNCTIONS IN INFANTS

The basic visual functions assessed in infants almost from birth are: pupi- lary reflex, alignment of eyes, fixation, smooth pursuit eye movement, generation of saccades, eye convergence, grating acuity (visual acuity based on preferen- tial looking), contrast sensitivity and peripheral visual field (22, 24-30). Later on, in preschool children who are able to understand matching tasks and follow simple instructions, almost all visual functions as in adults can be assessed: far and near visual acuity (based on recog- nition of optotypes), contrast sensitivity (presented by curve), color vision, dark adaptation, binocular vision (22, 24-36).

The pupillary reflex is the reduction of pupil size in response to light. Pupil reacts on direct light and also when the other eye is lightened (indirect light). The pupil response to light develops between 30 and 31 weeks’ postmenstrual age in preterm neonates (31). The blink to light, a reflex dependent on func- tioning photoreceptors, is present in all babies at 26 weeks’ postmenstrual age (32). During assessment direct and indi- rect pupillary reflex is tested by swinging flashlight test. It is important to notice size and shape of pupils and how rapid they constrict on direct or indirect light. The pupillary reflex can be inadequate because of damage on afferent or effer- ent pathways. If it is inadequate, espe- cially because of different pathways, too much light can come through and cause photophobia.

In newborns the intermittent strab- ismuss is frequently present, and at age of one month babies have normal ali- gnment of eyes (33). Binocular corre- lation ability, which means the capacity to generate a single image under dim light, is central on both eyes and symmetric very early in development of a child. In the case of asymmetric binocular reflex the cause has to be fo- und. If asymmetric refractive error is the cause, corrective lenses are necessary to prevent amblyopia. For other conditions, amblyopic therapy should be considered.

The critical sensitive period in the deve- lopment of amblyopia begins within the first weeks of life and lasts until about eight to ten years of age (http://www. aapf.org/afp/1999/0901/p907.html; http://aapf99/9901/p907-63) and this is also the period during which amblyopia may be reversed by treating the cause and stimu- lating visual development of the affected side (33, 34).

Visual fixation is the maintaining of the visual gaze on a single location. Full term babies show evidence of visu- al fixation at birth or shortly afterwards (35). Duration of visual fixation in in- fants aged 6 to 2 weeks varies depend- ing on object distance. It increases in time when objects are advanced to 30 centimeters (36). To estimate the positi- on and steadiness of retinal fixation point it is necessary to observe monocular corneal reflex. If the corneal reflex is central and steady we can assume that fixation is at or near macula where the vision is most distinct in daytime.

Smooth pursuit eye movements allow the eyes to closely follow a moving object. It is one of two ways that visual animals can voluntarily shift gaze, the other being saccadic eye movements. Smooth pursuit is present under two months of age. Development is most rapid during the first three months, but at six months it has still not reached the adult level (37). Stimulus characteristics can affect response rates and eye movement dyna- mics, particularly in young children (38). The understanding of eye move- ment performance in young children, it is important to use meaningful targets (38). Therefore, when assessing and comparing the oculomotor performance of children across studies, one must consider using targets such as human faces in increased contrast and objects form everyday use (mobile phone), be- cause they are more meaningful to chil- dren and, therefore, more interesting to look at.

Generation of saccades is essential for redirecting the fovea to different visu- al targets. From the age of at least 2 months, infants generate saccades with speeds similar to or slightly higher than those of adults (39). In the early age they

- Children under 12 months of age reach faster in the dark, and at 1 year of age reach faster in the light (64).
- There are researches about infant's reaching movements in light and dark. Visual feedback of the hand facilitates the age of reaching onset. However, the reaching movements become sufficiently stable, infants perform equally well with or without visual feedback (65).
- Activities of Daily Living (ADL) is a term referred to daily self-care activities performed at home, school, or work. It also can refer to independent living or residence, in outdoor environments, or both. Activities of daily living are the functions that are least well taught to visually impaired children. It includes activities such as physical, educational, and social skills required for self-care, household tasks, occupational tasks, leisure activities, and social interactions.
- Children with very low vision techniques or "sighted techniques" or "low vision techniques" or "sighted techniques" (62). Usually, very young children do not have time to develop compensatory techniques, so it is more important to answer basic questions we already mentioned: what, how and why?
- The measurement of visual functioning in infants can only provide an estimate of functional vision. The present visual acuity values and visual field recordings, which are used for classification, do not always correctly depict visual functioning even in older children. Although visual functions influence functional vision, more factors impose the performance of vision related tasks. Those factors can be person's non-visual abilities, such as motivation and level of activity, sensory processing (integration), level of intellectual functioning, physical development, personality, other co-impairments. Environmental factors can also influence visual functioning, for instance surrounding luminance, visual crowding, colors, shadows etc. Therefore, assessment of functional vision should be based on direct observation of how well various vision related activities can be performed by a child.
- The International Classification of Functioning, Disability and Health (ICF) for classification of functioning in adult people lists several functional areas as to be considered: learning and applying knowledge, general tasks and demands, communication, mobility, self care, domestic life, interpersonal interactions and relationships, life areas, community, social and civic life. Of the functional areas, domains of the ICF are functional areas of children. Those five are the same as where used in the WHO ICD 27. It recommends reaching milestones, assessing the main areas of functioning of children that exist in all cultures and in all age groups: communication and interaction, orientation and moving, everyday tasks, daily living (ADL) and sustained near vision tasks like reading and writing (58, 61). Visual functioning and abilities need to be assessed to one or four years and as in order to obtain solid foundation for planning early intervention and special education services (58). For each area of functioning we can describe behaviors of a child as "using blind techniques", "low vision techniques" or "sighted techniques" (62). During functional vision assessment in infants we have to observe the child's awareness of an object's position in relation to their own body and to objects in surroundings. The functional area of orientation and movement we are, also, assessing child's reaching movement. A reaching movement requires a certain level of interaction between infant and the environment, and represents an improved perception of the world and an understanding of some gamut of explorative actions (65). There are researches about infant's reaching movement in light and dark. Visual feedback of the hand facilitates the age of reaching onset. However, the reaching movements become sufficiently stable, infants perform equally well with or without visual feedback (65).
- Are we doing enough for our children? If we want to master situations that sighted children can do, than we have to consider the visual impairment binocularity. Is it because of non-meaningful target? Perhaps a child has a problem in action planning or motor execution? Once we answer those questions, we should be able to determine what treatment aspects would improve the whole functioning, such as reaching and grasping. Do we have to treat visual problems, adapt objects in surroundings, practice motor skills, or perhaps, all the mentioned?
- Research on infant spatial orientation, the ability to relocate a target following some form of bodily movement and/or reorientation (64). Visual and vestibular information are most important for space orientation and movement control. In recent study Bremner et al. (2011) reports that in normal environments visual input provides veridical information about the relationship between the individual and environmental features, providing direct information about the spatial relationship between self and the targets of actions (64).
- Currently available methods are based on a child's preference for black and white gratings of uniform density, depicted on cards with decreasing stripe widths. The location of the left/right position of the test stimulus has been randomly chosen. Assessor observes child's reaction looking at its eye or head movements. Looking of the child in the direction of lines indicated positive visual reaction to the stimulus. The threshold of acuity was considered as the finest stripe width for which the child consistently responds correctly. Acuity values are expressed in cycles per degree and can be compared to normative data reported in the literature (44, 45). Visual acuity in infants can also be tested by visually evoked potentials (VEP). Both techniques give meaningful and reliable, although bit better results of visual acuity in infants (46). Some more recent studies report about existence of larger difference between those techniques. Psychophysical methods generally yield lower absolute values in the preverbal age group (47).VEP acuity values preferentially acuity values obtained using gratings of different at different rates, converging to nearly equivalent levels by 12 months of age (48). Therefore, consistency is defined by the fatigability of the visual system within the normal limits, the answer to our basic questions can get very quickly, however, we should not jump to this conclusion, because we have to consider the problem of not seeing the problem. "What" could clarify the problem of not seeing the problem. Sometimes a child looks at a person, but smiles only on verbal and auditory cues and not on visual ones, than we have to consider the visual processing problems. And, when we are detecting visual problems, we have to make appropriate therapeutic and rehabilitative suggestions, such as adapting environment, prescribing lenses, treatment of social interaction problems etc.

- The measurement of visual functioning in infants can provide meaningful and reliable information about the visual acuity in infants. The finest stripe width for which the child maintains single binocular vision when looking at the visual stimulus. The visual acuity in infants is important and necessary in determining treatment plans for children and also for evaluating the outcomes (49). Contrast sensitivity measurements are important to see details at low contrast levels. Visual acuity at low contrast is especially important in visual communication, orientation and moving, everyday tasks and near vision tasks (50). There appeared to be two phases in the development of contrast sensitivity and acuity. Between four and nine months overall contrast sensitivity increases by a factor of 4-5 at all spatial frequencies. Beyond nine months, contrast sensitivity at low spatial frequencies remains constant, while sensitivity increases systematically at higher spatial frequencies (51). In preverbal children, contrast sensitivity, as well as acuity, can be assessed by preferential looking tests. Children is looking at black/white faces over a uniform field, depicted on cards with decreasing contrast. That testing in infancy and childhood gives important information about the distance at which the child can see facial features (52). Although, according to recent study, patients implanted with orange-tinted, yellow-tinted, or clear intraocular lenses displayed similar contrast sensitivity at different color targets on how to adapt environment in order to detect in surroundings, although it does not always mean the child is going to look at the object that size. Stimulus characteristics can affect response rates and eye movement dynamics, particularly in young children. As mentioned before, to avoid underestimation of eye movement performance in young children, it is important to use meaningful tasks (35). Through observation of how well various vision related activities can be performed by a child, we can have to think "why" the child is not reaching, if the child has a problem in functioning. Is it because of reduced visual acuity, impaired binocularity? Is it because of non-meaningful target? Perhaps a child has a problem in action planning or motor execution? Once we answer those questions, we should be able to determine what treatment aspects would improve the whole functioning, such as reaching and grasping. Do we have to treat visual problems, adapt objects in surroundings, practice motor skills, or perhaps, all the mentioned?
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- During assessment of communicational area we observe eye contact, facial expression, share emotions, ideas, thoughts, sounds, distance, gestures, signs, visual, tactile, auditory, and vocal language (62). These areas are consistent with the idea that an important aspect of visual functioning and personal identity is not understood that visually impaired children need to learn to master situations that sighted children can do, than we have to consider the visual impairment binocularity. Is it because of non-meaningful target? Perhaps a child has a problem in action planning or motor execution? Once we answer those questions, we should be able to determine what treatment aspects would improve the whole functioning, such as reaching and grasping. Do we have to treat visual problems, adapt objects in surroundings, practice motor skills, or perhaps, all the mentioned?
- Activities of Daily Living (ADL) is a term referred to daily self-care activities performed at home, school, or work. It also can refer to independent living or residence, in outdoor environments, or both. Activities of daily living are the functions that are least well taught to visually impaired children. It includes activities such as physical, educational, and social skills required for self-care, household tasks, occupational tasks, leisure activities, and social interactions.

During assessment of visual functioning, especially sustained near vision tasks, we have to consider child's ability of keeping visual attention. There are three main types of visual attention: spatial attention, which can be either overt, when an observer moves his/her eyes to a relevant area, and the focus of attention coincides with the movement of the eyes, or covert, when attention is deployed to relevant locations without accompanying eye movements. Regardless of their location; and, object-based attention in which attention is influenced or guided by object structure (72). Attentional processes develop over the human lifetime, and much of that development is due to concomitant changes in the brain regions controlling attention (73). In the early period of infancy, attention is directed primarily to salient visual stimuli of the environment and, by two or three years of age, comes under subject-directed control (73). The attention system co-evolves with control of the child’s eye movements and functioning and is used in the service of cognitive, social, and emotional tasks (73). There are numerous researches in the last four decades about sustained near visual attention (72-74). Nevertheless, in assessment of visual functioning is important to notice which objects catch a child’s attention and how long does a child keep the attention on an object? It, also, has to be observed is the attention easily distracted by other stimuli, such as tactile, auditory, proprioceptive etc (73).

REHABILITATION OF VISION IN INFANTS

Early detection and prompt treatment of vision problems in children is important to avoid lifelong visual impairment. The conceptual framework of early intervention is based on both neurobiological issues and developmental theories (75). Various neurobiological and neuroanatomical theories support the view that visual functions can be recovered (75). Developmental processes of the brain maturation persist after birth, particularly during the first years of life. These mainly apply to the processes of cortex organization that enables reorganization after brain injury, and therefore, functional recovery. This unique neurobiological process, the brain plasticity, seems to be confined to the first years of life. Rehabilitation and therapy can encourage brain plasticity and improve recovery of impaired function (76-81). Plasticity can be defined as the adjustment of the nervous system to changes in the external milieu (through sensory inputs) or internal milieu (through the effects of damage to the system) and appears to be mainly a property of the cerebral cortex rather than subcortical brain structures (82). In the planning of treatment it is important to know the developmental window for the structural-functional plasticity of the most severely affected neural systems (79). Kostovic and Jadrasic propose that an optimal time for an intensive treatment is at the end of the developmental window for a given neuronal system (79). As well as other infant-toddler studies, vision occurs most rapidly during the first years of life. Myelin in the optic nerve became fully developed by the age of seven months (83). Different cortical areas develop at different rates but at about six months after birth, basic circuits are in place (84).

Normal visual development requires environmental factors (i.e. sensory experience) and molecular programs that are genetically determined (85). The continuous sensory experience induces activity dependent tuning of synaptic connections (85). Visual experience is necessary for normal visual development (85, 86). We know that children born with congenital cataracts have permanent inability to recognize objects and if cataract removal is delayed until after age ten (85). Nearly half a century ago, Hubel and Wiesel proposed a feed-forward organization of cortex: the repertoire of different cell layers and columns. From their study of cats and monkeys visual cortex, the idea that the experience could contribute to constant and large changes in neural circuits emerged (87-92).

A review of trials, form Spittle et al. (2007), suggests that early development and intervention programs post hospital discharge are effective at improving cognitive development in the short to medium term (up to preschool age) for preterm infants (93). There is limited evidence that early developmental interventional treatments improve motor outcome or long term cognitive outcome (up to school age) (93).

Several authors studying rehabilitation of vision in infants with perinatal brain damage, found that visual stimulation and treatment improves attention and fixation times, pursuit movements and the capacity to perceive specific sacades, as well as the acquisition of environment scanning strategies, even grating acuity and contrast sensitivity (20, 76, 94).

Therefore, treatment of visual problems, using individual visual stimulation helps children to overcome visual damage to improve functional vision, especially the visual attention and visual communication, but also to achieve better fixation and pursuit (20).

There is no clear consensus on an exact definition of vision therapy. Vision therapy, also known as visual training, vision training, or visual therapy, is a broad group of techniques aimed at increasing, enhancing, or altering specific visual functions (e.g., ocularmotor, visual processing, and perceptual disorders) (95). Successful vision therapy outcomes are achieved through a therapeutic process that depends on the active engagement of the ophthalmologist, the vision therapist, the patient and in the case of children their parents. Overall, the goal of vision therapy is to treat vision problems that cannot be treated successfully with eyeglasses, contact lenses and/or surgery alone, and to help a child in achieving clear, comfortable binocular vision (96). It includes visual stimulation in early age and visual training later on in development.

The term visual stimulation could be defined as using of visual stimuli to make an infant or a child aware of vision. The objectives of visual stimulation programs are improvement of specific visual functions and functional vision. They are designed for each child individually according to functional vision assessment and according to the assessment in other developmental areas. In overall assessment we sometimes notice that it is more important to facilitate head and posture control than fixation or following eye movements.

Materials and methods for stimulatio n the vision are also chosen according to assessment results. Different kind of stimuli can be used, considering child’s visual functions and functioning:

- stimulation with everyday objects faces under normal lighting conditions;
- stimulation with bright colors and high contrast objects; using everyday objects, pictures, faces and toys with intensified colors and high contrast (made especially for visual stimulation);
- stimulation with objects under the UV light (different bright lights and high contrast objects are shown to the child in front of the black surface under the UV light which increases brightness and contrast);
- stimulation with lights and lighting objects (bright and dim lights and lighting objects such as flashlights, light sticks and others are used in the dark room) (20).

The child with low vision, as we noticed from our clinical work, has to be stimulated visually everywhere to achieve optimal visual development. Therefore, the parents have to be active partners in treatment and involve the visual stimulation in all everyday activities. Objects in use have to be adapted to stimulate visual vision. Low vision therapist must follow-up the child’s visual development, evaluate and modify objectively the approaches and methods of stimulation and support parents emotionally during the treatment. Children who may be actively involved in solving the tasks can do visual training. Visual training is the practice of exercising the eyes with the aim of overcoming visual disorders. The tasks in visual training are designed according to child’s abilities, not only visual, but also cognitive, gross and fine motor skills, communicational capacities and others.

CONCLUSION

To make right conclusions and to determine the most effective therapy, we have to observe the “whole child” during the assessment of functional vision. We have to be able to comprehend all areas of the development, because change in one function can cause altered functioning of the other, and it is sometimes very hard to identify the core reason for the specific functioning we see. Knowing the knowledge about the visual development, impact of visual impairment on other developmental areas and possibilities of vision therapy and rehabilitation is crucial for professionals working with infants and children with risk for developmental delays. These knowing will enable timely commence of rehabilitative procedures and therefore, optimal development within the child’s neurobiological capabilities.

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LITERATURE


Oštećenje vida u ranoj dobi ima vrlo složen utjecaj na djete i na cjelokupnu obitelj i zajednicu. Pravodobna intervencija bazirana na potrebitim stimulacijama može potaknuti djetetovo vizualno funkcioniranje i razvoj na svim područjima. Rano prepoznavanje i kvalitetna procjena djeteta s problemima u vizualnom funkcioniranju ključna je za pružanje pravodobne intervencije. Kvalitetna procjena obuhvaća procjenu vidnih funkcija, funkcionalnog vida i drugih djetetovih sposobnosti. Cilj ovog rada bio je prikazati osnovne vidne funkcije i parametre funkcionalnog vida koji se mogu procjenjivati u ranoj dječjoj dobi, te osnove funkcionalne rehabilitacije vida u djece. Opisane su razlike u definicijama vidnih funkcija i funkcionalnog vida. U opisu vidnih funkcija naglašeni su funkcionalni problemi koji proizlaze iz poremećaja određene funkcije. Prikazana su četiri glavna područja procjene funkcionalnog vida u ranoj dječjoj dobi. Zbog međusobne isprepletenosti utjecaja različitih oštećenja, poseban naglasak stavljen je na važnost procjene cjelokupnog djetetovog razvoja, ne samo problema u vizualnom funkcioniranju.

Deskriptori: OŠTEĆENJE VIDA, VIDNE FUNKCIJE, FUNKCIONALNI VID, PROCJENA, REHABILITACIJA VIDA, RAZVOJ VIDA, DJECA

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