DEVELOPMENT OF TRACKING OCULAR REFLEXES IN NEWBORNS IN ABIA SOUTH EASTERN NIGERIA

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ABSTRACT

Good visual acuity and the reflexes that are essential to normal functioning vision are not present in the newborn they develop with age. In this study, Children in Abia state of South Eastern Nigeria of age 0 to 48 months had their visual acuity, pursuit, saccadic and vergence reflexes enquired for with a behavioural observation method as the eyes tracked the stimuli of a steady speed. Visual acuity was measured as 20/600 by the 4th week of age and it improved to the standard 20/20 at the 48th month. Saccadic was earliest developed at the 8th week and was in all the population measured by the 18th week. Pursuit was developed by the 10th week and was fully established by the 21st week. The percentage with reflexes y, in the study population against age x, (in weeks) showed positive linear regressions. The estimated regression equation for saccadic, $\hat{y}$ = -61.16+9.52x and coefficient of determination, r2 =0.97. Pursuit, $\hat{y}$=-83.1+8.49x with r20.93. Vergence, $\hat{y}$=-52.77+6.36x and r2 =0.96. Failure of a child to present these maneuvers when expected could be indicative of a significant bilateral eye or brain abnormality; hence a referral for a more formal visual assessment is advisable.

Keywords: Visual acuity; Tracking; Pursuit; Saccadic; Vergence; Reflex; Newborns

INTRODUCTION

As we can only have sharp vision with good visual acuity from just one small region of our retina, we must be able to point this region of the retina at objects of interest if vision is to be of maximum use to us. Hence, eye movements are essential to normally functioning vision.

Several aspects of ocular development are still to be completed after birth.

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The retinal images are smaller compared to adults due to shorter distances from the retina to the cornea of the infants' eye. The muscles of the eye such as ciliary muscles that allow focus on particular objects through contraction and relaxation become stronger after two about 2 months of age [1].

From the point of view of binocular vision, bifoveal fixation does not exist at birth since binocular movement is not coordinated. Though monocular fixation presents at birth, it is only rudimentary since conscious fixation requires awareness of the presence of an object as well as enough interest to occupy one's attention. This mental activity is beyond the capacity of a newborn infant [2, 3].

With days monocular fixation of a large near object can be sustained. This alternates rapidly between the two eyes [1, 4]. Later, in an orderly sequence of ontology the child begins to fixate binocularly and to perform conjugate pursuit movements, following large near objects [1].

Vergence movements develop after version movements, fusional movement occurs at the same time but not firmly established [1].

This study is aimed at determining the visual acuity of infants at the different ages and to determine at what age saccadic, smooth pursuit and vergence reflexes are developed in the infant population.

METHODOLOGY

The study is a prospective study in which for the different ages of infant, the visual acuity was measured; and the presence of saccadic, pursuit and vergence reflexes were accessed.

A total of 11,520 infant population were examined. These consisted of 920 newborns of age 0 to 8weeks; 2,600 of 9weeks to 17weeks; 2,100 of 18weeks to 27week olds and 5,900 infants of ages 6months to 48month.

The infants were full term, defined as having birth weight greater than 2,500g, and gestational age of 38 weeks or greater based on the mother's report of her last menstrual cycle. The infants had no acute or chronic pre- or perinatal medical complications and were in good health at the time of recording. The infants had no obvious signs of strabismus and were not under pediatric or ophthalmologic care for visual difficulties.

Data collection

In the data collection or the assessment of the visual acuity, saccadic, pursuit and vergence the infant was held on the laps of the parent, caregiver, or assistant, and the target was shielded from the caregivers view in order to prevent bias.

Binocular Visual Acuity

The Optokinetic Nystagmus (OKN) drum was placed 18 inches in front of the child's eyes and gradually moved away from the child as the drum was rotated. The OKN response was observed, the distance at which the response ceased along with the width of the stripes on the drum gave the visual acuity of the infant [5]

Saccadic

The visual stimuli were the presentation of two brightly coloured Disney characters, circular in shape of 2°

diameter at 20cm apart in the horizontal; and 20cm from the infant; and 50cm from the observer that judged the infant's response.

When the observer judged that the infant was fixed at the first stimulus, the infant's attention was attracted towards the other target at 10deg/s speeds

The test was paused at random intervals for 10 seconds if the infant has fixated, or when the infant looked away from the target. The stimulus remained paused until the observer judged that the infant was looking at the stimulus for 5seconds.

Smooth Pursuit

The visual stimuli consisted of the presentations of a 2° diameter circular Disney character at approximately 20cm from the infant; and 50cm from the observer that judged the infant's response.

When the observer judged that the infant was looking toward the tracking stimulus, the target was moved at 10deg/s speeds in the horizontal across his eyes field; and by performing a rotational movement with the diameter of a circle being no more than 20cm. The stimulus was paused at random intervals for 10 seconds if the infant was tracking it, or when the infant looked away from the tracking target. The stimulus remained paused until the observer judged that the infant was looking at the stimulus for 5seconds.

Vergence

The visual stimuli consisted of presentations of a 2° diameter circular Disney character along the saggital plane starting from about 40cm to his nose and then away from his nose [1] at a speed of 1meter/seconds.

The stimulus was paused at random intervals for 10 seconds if the infant was tracking it, or when the infant looked away from the tracking target. The stimulus remained paused until the observer judged that the infant was looking at the stimulus for 5seconds.

Previous studies on observers' judgments of infants' looking at stimuli [6,7], resulted in interobserver agreement greater than 94%, so this study did not use a second observer to check for reliability of observer judgments.

Statistical analysis

The percentage of population demonstrating the visual skills was presented against the children's age in weeks. Using least square method the estimated regression equations and the coefficient of determination for the goodness of fit were calculated for the visual skills of saccadic, pursuit and vergence.

RESULTS AND ANALYSES OF DATA

Ocular reflexes in the 0 to 8weeks

In table 1, a total of 920 infants between 0 to 8 weeks old were examined. 40 infants were 4 weeks old; their mean visual acuity was 20/600. The 5 weeks olds were 150 in number and they presented a mean visual acuity of 20/400. Visual acuity measured 20/300 in the 8week old infants. Vergence and pursuit reflexes were not present in this 0 to 8week old population. Saccadic was present by the 8 week of age, and it was only in 20 (10%) of the 8week old infants.

Table 1: Visual Acuity and proportion of the population demonstrating the reflexes in the 0 to 8 weeks olds.

Population with the reflexes

Age No of infants mean saccadic pursuit vergence						
(wk)	examined binocular VA	N (%)	N (%)	N (%)		
0 15		*		x	x	x
1	20	*	x	x	x	
2	20	*	x	x	x	
3	20	*	x	x	x	
4	40	20/600	x	x	x	
5	150	20/400	x	x	x	
6	200	20/400	x	x	x	
7	250	20/400	x	x	x	
8	200	20/300	20 (10)	x	x	

920

* = not able to measure

X = not present in that age

Ocular reflexes in the 9 to 17weeks

A total of 2,600 infants were examined in this age group (Table 2). Visual acuity improved slightly to 20/250 in the 16 week and 17 weeks olds. Saccadic was present in 50 (16.7%) of the 9weeks. Saccadic increased steadily to 60% (150 out of the 250) in the 12week olds. In the15 week olds saccadic was present in 85.7% of the population of 200 infants. Pursuit was earliest noticed in 25 (6.25%) of the 10 weeks. Pursuit increased with age to be in 60% (120) of the17 week olds. Convergence was also present by 60% in the 17 weeks olds; convergence was earliest noticed in 10 (2.5%) of the 10 weeks olds.

Table 2: Visual Acuity and proportion of the population demonstrating the reflexes in the 9 to 17-week olds.

Population with the reflexes

(wk)	examined	binocular VA	N (%)	N (%)	N (%)
9 300	20/300	50 (16.7)	x	x	
10	400	20/300	130 (32.5)	25 (6.5)	10 (2.5)
11	250	20/300	120 (48)	25 (10)	20 (8.0)
12	250	20/300	150 (60)	50 (20)	60 (24)
13	250	20/300	170 (68)	70 (28)	80 (32)

14	300	20/300	230 (76.7)	100 (33.3) 140 (46.7)	
15	350	20/300	300 (85.7) 140 (40)	150 (42.9)	
16	300	20/250	280 (93.3)	150 (50)	160 (53.3)
17	200	20/250	195 (97.5)	120 (60)	120 (60)

2600

X = not present in that age

Ocular reflexes in the 18 to 26 weeks

Infants of a population numbering 2,100 were examined in the 18 to 26weeks. In the 18 weeks olds visual acuity still measured as 20/250. Visual acuity improved to 20/200 from the 24 weeks. The reflexes were fully developed in all the populations; saccadic was from the age of 18 weeks; smooth pursuit was from the age of 21 week and convergence from 25 weeks (table 3).

Table 3: Visual Acuity and proportion of the population demonstrating the reflexes in the 18weeks to 26 weeks olds.

Population with the reflexes

Age No of children mean saccadic pursuit vergence							
(week)	examined	binocular VA N (%)	N (%)	N (%)			
18 250	20/250	√		175 (70)	150 (60)		
19	250	20/250	√		185 (74)	175 (70)	
20	250	20/250	√		225 (90)	180 (72)	
21	200	20/230	√			√	180 (90)
22	200	20/230	√			√	190 (95)
23	250	20/230	√		√	220 (88)	
24	250	20/200	√	√	230 (92)		
25	200	20/200	√	√		√	
26	250	20/200	√	√	√		

2600

√ = present in all the population of that age

Visual acuity in the 6months and above

In this group (Table 4) a total of 5,900 infants were examined. In the 1,400 infants of "6 month to less than 12month" of age, visual acuity was measured as 20/150. In the 1,100 population of infants of age range "12 month to less than 24 months" visual acuity improved to 20/40. The standard adult acuity of 6/6 was attained from the 48 months.

Table 4: Age distribution of VA in the 6month to 48month olds.

Age (in months) No of children examined Mean binocular VA		
6 to < 12	1400	20/130
12 to < 24	1100	20/40
24 to < 36 1200	20/36	
36 to < 48 1000	20/30	
48 and above	1200	20/20
22	200	20/230
23	250	20/230
24	250	20/200
25	200	20/200
26	250	20/200

5,900

In the contest of the development of the individual reflexes, Visual acuity measured by optokinetic nystagmus reflex improved remarkable from a mean 20/600 at the 4th week to 20/400 at the 5th week. By the 8th week of life to the 15th week, acuity was maintained at 20/300. It improved to 20/200 by the 24th week. From the study the acuity still remained as poor as 20/100 in "6month to less than 12month" of age. The infants attained the standard adult acuity of 20/20 by the 48month of life and above.

Saccadic was present at the earliest by the 8th week of age in 20 (10%). Its development increased and was present 16.7% (of the 300) of the 9th week and 60% (150 of the 120) of the 12th week. By the 15th week more than 85% (300 of the 350 infants) have acquired saccadic. Saccadic was fully developed, 100% (250 of the 250 infants) by the 18th week.

The percentage of populations with the visual reflex saccadic y, against age x, in weeks appears to be approximated by a straight line, which is positive. With the estimated regression equation as $\hat{y}$ =-61.16+9.52x; and a coefficient of determination, r^2=0.97

Pursuit begins at the 10week in the study, at which 6.25% (25 of the 130 of the infants) have developed pursuit movement. Pursuit was gradually gained to 10% (25 of 250), 20% (50 of the 250) and close to 30% (70 of the 170) by the ages of 11, 12 and 13weeks. Pursuit was developed in 50% (150 of the 300 infants) by the 16th week. Pursuit was in 70% (175 of the 250), 74% (185 of the 250) and 90% (225 of the 250) in the 18, 19 and 20week olds respectively. Pursuit was developed in 100% of all the infants examined at the age 21weeks. The percentage of the population with the visual reflex smooth pursuit y, against age x, in weeks appears to be approximated by a straight line, which is positive. With the estimated regression equation as $\hat{y}$ =-83.1+8.49x; and a coefficient of determination, r^2=0.93.

Vergence movements develop at the earliest by the 10th week, at which 2.5% (10 of the 400) of the infants examined where able to follow an object as it moved closer to the eye. Vergence development in the population became 24% (60 of the 250) by the 12th week. By the 16th week more than half the population 160 of the 300

(53.3%) have developed vergence. Vergence was in 60% (150 of the 250), 70% (175 of the 250) and 90% (180 of the 200) by the 18th, 19th and 21st weeks of life respectively. By the 25th week, 100% (200 of the 200) of newborns all have acquired vergence movement.

The percentage of the population with the visual reflex vergence y, against age x, in weeks appears to be approximated by a straight line, which is positive. With the estimated regression equation as $\hat{y}$ =-52.77+6.36x; and a coefficient of determination, r^2=0.96.

DISCUSSION

The results of this study at the first weeks of age compares with the work of Courage and Adam [8]. They gave the visual acuity for infants under one month of age as ranging from 20/800 to 20/200; and this study gives the acuity of the 4week olds as 20/600. This study's results were quite different with Courage and Adam [8] for their 2months which was reported as 20/150, and the 4months as 20/60. This study recorded a poorer visual acuity of 20/300 by the 8week of life to the 15th week. The studies also disagree with the age of attainment of the standard adult acuity of 20/20. They reported as 6month, and this study reported at the 48month. Other works did not measure the standard acuity at an earlier age, Cavallini *et al.,* measured 7/10 (20/30) at 24months [9], and Pan *et al.* reported that the VA develops to 20/20 well after the age of six in most children [10].

The measurement of visual acuity in infants is not always possible with a letter chart. Testing is by using a series of black and white stripes in preferential looking techniques or electro-physiologic testing of visual evoked (cortical) potentials. It is important to note that differences lie in the results from the various methods used in VA measurements in children.

In adults and older, verbal children capable of paying attention and following instructions, the endpoint provided by the visual evoked (cortical) potentials VEP corresponds very well to the psychophysical measure in the standard letter chart. The assumption is that this correspondence also applies to much younger children and infants.

For reasons not totally understood, until a child is several years old, visual acuities from behavioral preferential looking techniques typically lag behind those determined using the VEP, a direct physiological measure of early visual processing in the brain. Possibly it takes longer for more complex behavioral and attentional responses, involving brain areas not directly involved in processing vision, to mature. Thus, the visual brain may detect the presence of a finer pattern (reflected in the evoked brain wave), but the "behavioral brain" of a small child may not find it salient enough to pay special attention to.

In the stimuli trackings, initially, the infants were slow to initiate saccadic movements; there was a delay before the response of the saccadic eye movement was seen. The movements also look different from those of an adult in that they tend to make a series of much smaller movements, very much like sequence of small hops instead of one big jump. Starting at an initial 10% of the population at 8th wk, the gain was improved upon quickly with age, that at the 18th week, 100% of the population had saccadic eye movements that are normally looking. This is coherent with Phillips *et al.* [11].

For pursuit, the infants could only follow very slowly moving objects, and even at then their movements are jerky rather than smooth. In agreement with von Hofsten and Rosander [12, 13], only 6.25% of 10wk olds were capable of a smooth pursuit movement; and by the 21st week it was present in all the children examined.

The essence of saccadic and smooth pursuit reflexes is that tracking of a stimulus moving across is by saccadic and pursuit eye movements. Tracking switches from saccadic in the earlier weeks to following the stimulus with smooth pursuit eye movements in the later weeks. At the 14-week of age, with 76.6% of the population with saccadic and 33.3% with smooth pursuit, the overall stimulus tracking was about two–third by saccadic and one-third by pursuit. For the 21 weeks olds and above especially during sustained attention overall tracking was by smooth pursuit.

The study was at a steady speed of 10deg/sec., at an attempted higher stimulus speeds, though not reported in this study, there were decreases in smooth pursuit tracking and compensation was made by increasing saccade amplitude. That is, with increases in stimulus speeds tracking shift from smooth pursuit tracking to saccadic tracking, when smooth pursuit tracking began to fail.

Some of the results from this study compare fairly with that of Von Hofsten and Rosander [13] and the study by Phillips *et al.* [11]. Some of the differences in this study were probably due to the nature of the stimuli. This study used a relatively simple brightly coloured Disney character of 2° wide. Whereas the stimulus used in the Von Hofsten and Rosander [13] study was a schematic face that was 10° wide. The smaller stimulus of the study may have been more difficult to track than the large face. Several studies have shown that very large targets (6° to 16°) at slow speeds are tracked by infants at young ages of one month [12]. Secondly the differences among these studies also may have been due to infant head movements. The study restrained the infant's head movements, but in the studies of Phillips *et al.* [11] and Von Hofsten and Rosander [13] they allowed head movements. Infants generally track stimuli with head movements. Hence their estimates on development of smooth pursuit eye movements may have been artificially lowered because some of the tracking was done with head movements.

Infants are capable to turn their eyes inward towards each other and outward away from each other to maintain single vision with the two eyes as they look at objects closer and further away respectively. In Thorn *et al.* [14], it is reported that the onset of sensory binocular fusion is at 12.8 ± 3.3 weeks and full convergence at 13.7 ± 3.2weeks. The scope of this study did not extend to sensory fusion reflex; but then the result of Thorn *et al.* [14], on convergence showed a late development in our populations in which convergence was full at 25weeks; with the earliest development at 10weeks (2.5% of the population). This difference could lie with the speed at which his target approached the infant's eyes, which was not reported. However as expected, for his results and this there was a high correlation between age and convergence. It is said that vergence develops after version [1], but referring to the table of this study, this was not all very true. Pursuit a form of version movement was acquired later after vergence in most children between the ages of 12 weeks and 16 weeks. There was 24% of 12 weeks with established vergence reflexes and a lesser, 20% with pursuit. The 13 weeks old had 32% vergence and 28% pursuit. The 17 weeks olds demonstrated pursuit and vergence reflexes by an equal 60%). The explanation could not be sort in the inherent limitations of the study, which were addressed in the methodology by repeating measurement as necessary. The clinical testing of smooth pursuits and saccades have the potential for bias because of its subjective nature and is very challenging to undertake accurately given the relatively short concentration span of infant. Saccadic eye

movements, smooth pursuit, and vergence have distinct anatomic substrates and physiological organization [15]. Thus, the immaturity and cerebral abnormality encountered in children who were born pre-term can limit distinctively. As a second limitation, the study relied on the mothers account to term the gestation of the newborns as full terms.

CONCLUSION

Normal functional vision and most ocular reflexes are not present in the newborn; they are acquired, that is they are developed with age.

- Visual acuity of newborns at 4weeks of age was measured as 20/600.
- Infants attain the standard 6/6 acuity at 48 months of age.
- Saccadic reflex was earliest noticed at the 8th week.
- Saccadic reflex was present in all the infant population by the 18th week.
- Smooth pursuit reflex was earliest noticed at the 10th week.
- Smooth pursuit reflex was present in all the infant population by the 21st week.
- Vergence reflex was also earliest noticed at the 10th week.
- Vergence reflex presents in all the infant population at the age of 25weeks.

RECOMMENDATION

Appropriate vision testing at these early ages is recommended to ensure that a child has the visual skills needed for learning and development.

If a child fails to demonstrate the reflexes after the expected age, a referral for a more formal visual assessment is advisable.

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