CHAPTER 2

METHODOLOGY

2.1 STUDY BACKGROUND

We conducted the study in various schools for children with special needs namely SPASTN (Spastic Society of Tamilnadu), Aravind Foundation (K.K.Nagar), Vidyasudha (School for children with special needs) in Sri Ramachandra Medical College, Chennai. We performed both subjective and objective assessments to collect various parameters of visual functions in children with Cerebral palsy based on physician’s diagnosis and disability certificate submitted in the school records. Children with motor impairments without Cerebral Palsy were excluded in the study. Informed consent forms were provided both in English and vernacular language to all the subjects’ parents; it was also orally read for illiterate parents before recruiting the subjects. Birth history of the child was noted.

Data on normal visual development is not available on an Indian population. Data on Indian children are likely to be different from our western counterparts due to genetic profiles and environmental factors. Hence all the visual functions in normal children in our population with the age match of the previous data collected on children with cerebral palsy were also assessed.
Methodology

2.2 RESEARCH PLAN

- Prospective Descriptive Study
- Sample Size calculation: The prevalence was given based upon the prevalence of cerebral palsy in previous literatures. Prevalence of Cerebral Palsy is 1.25% per 1000.
- 40% prevalence of ocular abnormalities amongst the children with Cerebral Palsy. Hence the number of controls would be the same for the normative data collection

SAMPLE SIZE CALCULATION:

Prevalence = 40%

Q = 60 %

Sample size = \( 4 \frac{PQ}{L^2} \) or \( \frac{(1.96)^2 PQ}{L^2} \) (P) \[ \begin{align*}
L &= 10 \times 40 / 100 \\
&= 3.84 \times 40 \times 60 / 100 \times (5\% \text{ of } P) \\
&= 368 \\
\text{If } L &= 20 \% \text{ S.S } = 144 \\
\text{If } L &= 15 \% \text{ S.S } = 256 \\
\text{If } L &= 5 \% \text{ S.S } = 368.7
\end{align*} \]

The sample size of our study was 368

INCLUSION CRITERIA

- Cerebral Palsy based on physician’s diagnosis and disability certificate submitted in the school records
- Age group : 5 months - 18 years
- Multiple disabilities with Cerebral Palsy involved.
EXCLUSION CRITERIA

- Pseudophakia
- Any history of Ocular surgery

METHODOLOGY

RECRUITMENT OF SUBJECTS

Screening Tests

Diagnostic Tests

SCREENING TESTS

- Assessment of Visual Functioning
- Motor Functions

DIAGNOSTIC TESTS

Static retinoscopy

- Cycloplegic
- Non-Cycloplegic

Dynamic retinoscopy

Inclusion Criteria for typically developing peer (Control) group:

Three hundred and twenty eight children were drawn from Department of Ophthalmology and Department of Pediatrics who did not visit for any visual issues at Sri Ramachandra University. Based on the following criteria:

Age group: 5 months to 18 years (age match of the children with Cerebral Palsy in the study).
Methodology

Exclusion Criteria:

- Neurological disorders
- Ocular disorders
- Genetic disorders

Methodology:

The tests were be performed by the same examiner to avoid examiner bias.

The following are the tests performed to assess the visual function

- Sensory tests-three grades of binocular vision
- Visual acuity assessment
- Colour vision
- Motor Functions-Accommodative response
- Visual fields- Lea flicker wand
### Methodology

**Visual Functions**

<table>
<thead>
<tr>
<th>Able to actively participate and respond</th>
<th>Limited participation and responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory tests:</td>
<td></td>
</tr>
<tr>
<td>Stereopsis</td>
<td>Randot</td>
</tr>
<tr>
<td>Fusion: Central</td>
<td>Worth Four Dot Test</td>
</tr>
<tr>
<td>Peripheral</td>
<td>Distance</td>
</tr>
<tr>
<td></td>
<td>Near</td>
</tr>
<tr>
<td>Oculomotor functions:</td>
<td></td>
</tr>
<tr>
<td>Squint assessment</td>
<td>Hirschberg’s test</td>
</tr>
<tr>
<td>Accommodation</td>
<td>Dynamic Retinoscopy</td>
</tr>
<tr>
<td></td>
<td>Hirschberg’s test</td>
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<tr>
<td></td>
<td>Dynamic Retinoscopy</td>
</tr>
<tr>
<td>Visual Acuity</td>
<td>Lea Symbols</td>
</tr>
<tr>
<td></td>
<td>Lea paddles/ Fixation pattern test</td>
</tr>
<tr>
<td>Colour Vision</td>
<td>Ishihara’s chart</td>
</tr>
<tr>
<td></td>
<td>------</td>
</tr>
<tr>
<td>Visual-fields</td>
<td>Lea flicker wand</td>
</tr>
<tr>
<td></td>
<td>Lea flicker wand</td>
</tr>
</tbody>
</table>

- Static retinoscopy – to assess the refractive status
- Dynamic retinoscopy - to assess the accommodative response
- Cycloplegic retinoscopy - to confirm the refractive status (controlling the ciliary muscle action).
Fig 5: Tools used for visual function assessment for children with CP and control group
METHODOLOGY (CHILDREN WITH CP)

Visual Function Assessment (Screening tests) (Phase 1)

Static Retinoscopy (non-cycloplegic and cycloplegic refraction) (Diagnostic tests) (Phase 2)

Prescribe Glasses

Assessment of Accommodative status- MEM Retinoscopy (Dynamic Retinoscopy) (Phase 3)

If lag of accommodation > +1.25 DS /lag of accommodation

Yes                                  No

Change of glasses                     same glasses

Follow – up with (after 4 weeks) (II Visit)

Visual acuity testing Spectacle compliance

Assessment of Accommodative status- Dynamic Retinoscopy (MEM method)

If lag of accommodation > +1.25 DS /lag of accommodation

Yes                                  No

Change of glasses                     same glasses
METHODOLOGY (Normal children)

Screening tests
(Visual function assessment)
↓
Diagnostic tests
↓
Static Retinoscopy
↓
Dynamic Retinoscopy (MEM Retinoscopy)
Assessment of Accommodative status
↓
Cycloplegic refraction
(to confirm the refractive status)

Procedures for protection of human subjects in this study were handled with approval from the Institutional Ethical Review Committee of Sri Ramachandra University. Written informed consent were collected from the study participants/Parents/Guardian. Every participant was given a study-specific ID number. The databases collected were accessed only by the researchers named in the research proposal and approved by the ethical committees.
**Methodology**

Refractive and Accommodative status among the children with Cerebral Palsy in three special schools of Chennai and the impact of the optical intervention on the visual acuity and accommodative response

**Fig 6: Assessment of visual functions in children with CP**

**HISTORY TAKING:**

Under history taking, the type of Cerebral Palsy under which the child belongs to was recorded. This helps in comparing the refractive status among the different groups of the Cerebral Palsy classification. History of seizures was also recorded. Detailed birth history that includes pregnancy period, type of delivery, birth color, birth weight, history of incubation, oxygenation, asphyxia, gestational diabetes and hypertension was also recorded. If the child had siblings, their information about their status was also recorded.
Methodology

VISUAL ACUITY:

The ability to resolve a detail is referred as "Visual acuity" (36). Lea Paddles and Lea Symbols were used to assess the visual acuity in the children (37). If the child does not respond consistently to the Lea Paddles or Lea Symbols, their visual acuity was determined by their Fixation pattern. Most children may not be able to speak, but may still be able to respond to an optotype recognition test, if we are creative in providing solutions. Children can point at the symbols on an answer key in the order they are seen on the test. Visual acuity tests are available for both distance and near. When testing children with visual impairment, we allow the child to pick a distance that is comfortable and natural to them. According to WHO the luminance levels should be between 80 to 160 cd/m².

TEST SELECTION:

Visual acuity value usually refers to the size of the smallest optotypes (characters, numbers, and paediatric symbols) that the child could recognize. Some children and all infants cannot be tested with optotype tests because they do not have the concept of same/different for symbols, and cannot match. These children are tested with detection tests.

VISUAL ACUITY ASSESSMENT USING FIXATION PATTERN:

The presence of any eye movements and the maintenance of fixation were noted. Here, a spot light was shone in front of one eye and the eye being covered. Then, presence of any eye movements was noted followed maintenance of the fixation while the eye was uncovered. If the eye had center corneal reflex, steady eye and maintains fixation, it is noted as Central, Steady and Maintained (CSM).
Methodology

RECOGNITION ACUITY:

The ability to identify or recognize the smallest detail by the visual system of a person is known as Recognition acuity. It is the most common measure of spatial vision and involves the resolution of feature differences in familiar targets. Typically, the observer identified lines of letters presented on a screen or chart. Lea symbol chart was used to measure recognition acuity. Even the smallest size of the optotype identified by an individual could be determined using Lea Symbols (38),(47).

DETECTION ACUITY:

The highest spatial frequency with the ability to discriminate luminance gratings from a uniform field is defined as Detection acuity. This type of acuity is measured with Lea paddles during preferential looking situations (46). Lea grating was the standardized way of assessing detection acuity that uses black and white gratings in a preferential looking situation Lea Paddles were used. 0.25, 0.5, 1, 2, 4 and 8 cpcm (cycles per centimeter of surface) are the grating levels printed on each handle. Finer and finer grating targets would be shown before the infant along with a grey plain surface of similar luminance (48). One white and one black stripe together form one cycle. When a grating is held at 57 cm from the infant’s face, one centimetre equals one degree (cpd) at the distance used. A grating target covers a much larger area of the central visual field than optotype acuity values, thus grating values are often significant than optotype acuity values.
Methodology

Grating acuity at different distances

Cycles per centimeter (cpcm) is the frequency of grating printed on each paddle. The cycles per degree (cpd) is the measure of grating acuity. It is calculated using the formula given below:

(Distance used/57.2cm) x cpcm = Cpdm

The paddle is considered as a circle which is 360°. The circumference of a circle is equal to \(2\pi r\) (where \(r\) = the radius). Here, “r” is the distance between the child’s eye and the paddle. Therefore, each degree of angle subtends to a distance of 1 cm on the circumference of a circle would be 360 cm.

Hence, the radius of such a circle is then calculated as;

\[
r = \frac{360}{2\pi} = 57.2\text{cm}
\]

At the distance of 57cm (22.5”), 1 centimeter equals 1 degree of visual angle. If the distance increases more than 57cms, cpd increases. The table below gives the cpd values for various distances. If another distance is used, the cpd results can be calculated using this formula.

**TABLE 1: Grating acuity reported in cycles per degree (CPD)**

<table>
<thead>
<tr>
<th>Distance in cm (Inches)</th>
<th>Cycles Per Centimeter (cpcm): Printed On Paddles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>29 cm (11.5”)</td>
<td>0.12 Cpd</td>
</tr>
<tr>
<td>57 cm (22.5”)</td>
<td>0.25 Cpd</td>
</tr>
<tr>
<td>86 cm (34”)</td>
<td>0.40 Cpd</td>
</tr>
</tbody>
</table>
Methodology

VISUAL FIELDS

Lea Flicker wand was used to measure the visual fields in the children. It has a diode of 20” (50.8 cm) at the end could be used either as flickering or non-flickering stimulus at 10 Hz at luminance levels 4, 40 and 400 cd/m2. It is flexible wand of 26.5” (67.3 cm) in length.

This curved wand was stimulated forward from the back of the child in all four quadrants of the visual field to identify the peripheral visual field loss. The non-flickering weak light measures the smallest visual field and was often the best stimulus to estimate scotomas. The examiner was seated in front of the child who looks at the tester’s eyes or the tester stands slightly on the side of the child who keeps looking at an interesting target, e.g. a video camera. The examiner watches the eye movements of the child and brings the stimulus forward at the moments when the child’s eyes are in the midline (39).

OCULO-MOTOR STATUS:

Tropia (Manifest Strabismus or squint) is the manifest deviation of the eyes

EXOTROPIA (XT):

Manifest outward deviation of the eye

ESOTROPIA (ET):

Manifest inward movement of the eye

HIRSCHBERG’S METHOD:

An estimation of ocular alignment. This is not a precise measure of motoric alignment, but will give a good estimation. It is usually the test of choice...
in very small children who are unable to hold fixation for a cover test (40). It can be used to rule out conditions like pseudo-strabismus which is the appearance of a strabismic eye, when the eyes are straight. It is often caused by prominent epicanthal folds or an especially large or small papillary distance. The magnitude of any tropia can be estimated by using the following conversion factor. 1 mm of displacement is equal to 2∆ of deviation. The millimetres of displacement are measured from the monocular position.

**Fig. 7: Hirschberg’s Test - Corneal light reflex**

If the corneal reflex is:

- At the Centre of the pupil - ortho
- At the pupillary margin - 15° (30 prism diopters)
- Between the pupillary margin and limbus - 30° (60 prism diopters)
- At the limbus - 45° (90 prism diopters)

A corneal light reflex displaced temporally will indicate an

**Fig 8: ESO deviation.**
Methodology

A corneal light reflex displaced nasally will indicate an

![OS Exotropia](image)

Fig 9: EXO deviation.

A corneal light reflex displaced upward will indicate a hypo deviation.

![OS Hypotropia](image)

Fig 10: Hypotropia

A corneal light reflex displaced downward will indicate a hyper deviation.

![OS Hypertropia](image)

Fig 11: Hypertropia

NYSTAGMUS

Nystagmus is an involuntary, repetitive, rhythmic movement of the eyes either with same amplitude, equal or unequal velocity in both the directions. (50).

Various forms of nystagmus are congenital, acquired and spasmus nutans.
Congenital: It occurs since birth usually by 2 to 3 months of age. It is always associated with other conditions like underdeveloped optic nerves, aniridia, albinism and congenital cataract.

Acquired: Occurs during adulthood may be due to metabolic or central nervous system disorders, drug toxicity or alcoholism. Generally the cause is not known.

Spasmus Nutans: The children would have head nodding and a head tilt, eyes may move in any direction. It often occurs between 6 months and 3 years of age and resolves spontaneously by 2 to 8 years of age. Hence it does not require treatment.

**STATIC RETINOSCOPY**

The refractive status of the eye is assessed by performing Static retinoscopy. It works based on Foucault's principle. This procedure is performed while the subject fixates at an object at 6mt distance. A power equivalent to the working distance is subtracted from the gross retinoscopy value to simulate optical infinity by the examiner and to record accurate refractive status of the eye. The refractive power of the eye would be neutralized with the appropriate power lenses based on the movement of the reflex. Myopes would have an "against" reflex and hyperopes would have "with" movement. "Against reflex" would be neutralized with minus lenses and "with reflex “would be neutralized with plus lenses.

Mohindra near retinoscopy is used in determining the refractive status of infants and children. It is performed in complete darkness, with the child fixating the retinoscopic light. It is a monocular procedure, the eye not being examined being occluded and an adjustment factor of minus 1.25 DS is algebraically
Methodology

combined with the spherical component of the gross sphero-cylindrical lens powers.

Following the Mohindra near retinoscopy, cycloplegic refraction was done. In that method, the refractive status of the child was measured with accommodation at rest by instilling 1 drop of 0.5% cyclopentolate Hcl in each eye and then 1% Tropicamide one drop in each eye was instilled after that the patient was asked to stay with his/her eyes closed for 30 minutes, retinoscopy was performed after half an hour (41).

REFRACTIVE STATUS

EMMETROPIA:

The normal refractive state of the eye in which, with accommodation relaxed, parallel rays of light will converge to a sharp focus on the retina (42).

AMETROPIA:

A refractive condition other than emmetropia in which, with accommodation relaxed, parallel rays of light fall to converge to a sharp focus on the retina. It consists of myopia, hyperopia and astigmatism.

MYOPIA:

A refractive anomaly, when accommodation is at rest, parallel rays of light converge to focus in front of the retina.
Methodology

DEGREE OF MYOPIA

LOW : < -3.00DS
MODERATE : -3.00 to -6.00DS
HIGH : > -6.00DS

HYPEROPIA:

A refractive anomaly, when accommodation is at rest, parallel rays of light converge to focus behind the retina

DEGREE OF HYPEROPIA

LOW : < +2.00DS
MODERATE : +2.00 to +5.00DS
HIGH : > +5.00DS

ASTIGMATISM

As the refracting power of the eye varies from one meridian to another, a point image would not be formed for a point object.

DEGREE OF ASTIGMATISM

LOW : < 2.00 DC
MODERATE: 2.00 to 5.00 DC
HIGH : > 5.00 DC
TYPE OF ASTIGMATISM BASED ON THE MERIDIAN:

With-the-rule (WTR):
If the refracting power of the eye is greater in the vertical meridian than in the horizontal meridian, it is With-the-rule astigmatism.

Against-the-rule (ATR):
If the refractive power of the eye is greater in the horizontal meridian than in the vertical meridian, it is Against-the-rule astigmatism. (43).

CLINICAL TYPES:

SIMPLE ASTIGMATISM:
Astigmatism in which, with accommodation relaxed, one focal line is located on the retina and the other is located in front of the retina (simple myopic astigmatism) or behind the retina (simple hyperopic astigmatism).

COMPOUND ASTIGMATISM:
Astigmatism in which, with accommodation relaxed, both focal line are located in front of retina (compound myopic astigmatism) or behind the retina (compound hyperopic astigmatism) (44).

MIXED ASTIGMATISM:
Astigmatism in which, with accommodation relaxed, one focal line is located in front of the retina and other behind the retina (44).
TABLE 2: Age-matched refractive error in normal children

(Western population)

<table>
<thead>
<tr>
<th>Author</th>
<th>Age</th>
<th>Mean Refraction (In Dioptres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutti et al</td>
<td>3 Months</td>
<td>+2.13 (±1.31)</td>
</tr>
<tr>
<td>Santonastaso</td>
<td>0 – 3 Months</td>
<td>+1.67 (±2.54)</td>
</tr>
<tr>
<td>Mayer et al</td>
<td>1 Month</td>
<td>+2.20 (±1.60)</td>
</tr>
<tr>
<td>Mutti et al</td>
<td>9 Months</td>
<td>+1.32 (±1.07)</td>
</tr>
<tr>
<td>Mayer et al</td>
<td>12 Months</td>
<td>+1.57 (±0.78)</td>
</tr>
<tr>
<td>Mohindra &amp; Held</td>
<td>65 – 128 Weeks</td>
<td>0.43 (±1.32)</td>
</tr>
<tr>
<td></td>
<td>129 – 256 Weeks</td>
<td>0.59 (±0.85)</td>
</tr>
<tr>
<td>Ingram &amp; Barr</td>
<td>1 Year</td>
<td>0.62 (±1.11)</td>
</tr>
<tr>
<td></td>
<td>3 - 5 Years</td>
<td>0.95 (1.11)</td>
</tr>
<tr>
<td>Blum et al</td>
<td>5 – 15 Years</td>
<td>Slow decline from mean of +0.62 DS at age of 5 yrs to +0.12 DS at age of 15 yrs</td>
</tr>
<tr>
<td>Hirsch</td>
<td>5 -14 Years</td>
<td>slow decline from mean of +0.80 DS at age 5yrs to +0.35 at age of 14 yrs</td>
</tr>
</tbody>
</table>
EMMETROPIZATION

Active Process

The active process mechanism theory proposes that emmetropization is regulated by the retinal image. The eye analyzes the amount of retinal blur, and proportionally elongates or shortens until the image and retina are conjugate. Various observations are used to support the concept that emmetropization is an actively regulated visual process. One is provided by the refractive outcomes of visually deprived human neonates. The development of the refractive state in human neonates is very sensitive to visual disturbances. It has been shown that in this population visual deprivation from corneal opacifications, congenital cataracts, lid aperture, vitreous hemorrhage, and retinopathy of prematurity cause the eye to elongate and therefore fall farther away from emmetropia. A study of twins had shown one twin with media opacity to have a 2.0mm longer eye than the contra lateral eye or the axial length of the twin brother’s eyes. This would equate to about 6.00 D differences in refraction between the normal eyes and the visually deprived eye, based on the ratio of 1mm to 3.00 Diopters (45).

A second observation to suggest that emmetropization had an active component is the association of sustained near vision and myopia. It is not uncommon to find the onset or increase in myopia associated with close visual tasks.

Passive Process

The passive theory suggests that occurs as a result of physical and genetic determinants of normal eye growth. As the infant physically grows, the degree of
initial myopia or hyperopia decreases. This is caused by the appropriate proportional interactive changes of the dioptric components and axial length. Thus, both myopic and hyperopic eyes gravitate towards emmetropia. Sorby, et al., have described the natural alteration of ocular components to include axial lengthening in concert with lens and corneal power reduction.

**ACCOMMODATION:**

It is the process by means of which the optical system of the eye varies its focal length in response to visual stimuli.

**THE MECHANISM OF ACCOMMODATION**

Accommodation is a route for the change in the dioptric power of the crystalline lens which creates in-focus retinal image of an object at the fovea. A variety of ideas have been proposed regarding how we see clearly at different distances.

**Some of them are as follows.**

1. There is no need for an active form of focusing. This radical notion was accounted for by judicious use of the interval of Sturm in uncorrected astigmatism and appropriate placement of the depth of focus in all other situations. Clearly this is insufficient to explain the clarity of vision and large range of accommodation found in children and young adults.

2. Pupil size changes with the effort to see clearly at near. However, the depth of focus for the smallest normal physiological pupil diameter
(approximately 2.0 mm) in pre-presbyopes again can account for only a small portion of their accommodative amplitude (46).

3. Corneal curvature change with a change in focal point (47). As Thomas Young demonstrated over 200 years ago, however, when he immersed his cornea into a beaker of water and thus neutralized its power, accommodation was still possible. Therefore, the cornea is not a factor in the accommodative process.

4. The anteroposterior position of the lens changes with variation in focal point. This theory has been discounted by a variety of techniques, including biomicroscopy and ultrasonography. Moreover, given the small range over which the lens could theoretically shift in the human eye, the changes in power would be rather small and, again, could not begin to equal the 15.00 or so amplitude found in young children (48).

5. Changes in the axial length of the eyeball itself account for shifts in the position of the retinal image for objects at various distances (47). Again, Young,' with his large, protruding eyeballs and considerable commitment, provided the disconfirming evidence for this theory. Placing a clamp near the anteroposterior axis of his own eye, Young demonstrated that the size and intensity of the mechanical-pressure-generated phosphene did not change with accommodation. Thus, the eye did not change in axial length. This theory has also been discounted for the most part with clinical ultrasound. However, minute changes in axial length 0.040 (equivalent) with accommodation have been found using laboratory-based partial coherence interferometry."
6. Change in the shape and power, of the crystalline lens makes objects at different distances to get focussed on the retina. By both default and available evidence and logic, this is clearly the correct mechanism of the human accommodative process. The only active element is the ciliary muscle. All other elements act in a passive manner (49). For example, when the ciliary muscle contracts, it pulls the ciliary ring forward and inward and stretches the choroid and posterior zonules. When the ciliary muscle subsequently relaxes, the passive restoring forces of the spring-like choroid and posterior zonules return each element to its former position (49).

![Figure 12: Mechanism of accommodation](image)

**Figure 12 : Mechanism of accommodation**

**Development of Accommodation**

Considerable insight has been gained in the past 30 years or so into the accommodative ability of young infants. Accommodative stimulus-response profiles were determined in infants whose ages ranged from 6 days to 4 months.
Accommodation during the first month appeared to be relatively fixed at approximately 5.00 D, whereas in the subsequent 3 months it progressively became more accurate and approached adult-like behavior. In a later study using a more compelling stimulus array, Banks found more mature accommodative ability in young infants, especially during the first month of life. The calculated depth of focus showed to be large in the first month and decreasing considerably over the next 2 months. It appeared that infant accommodation was dictated by the level of neuro-sensory development and sensitivity at the time of testing. However, reasonable blur sensitivity can be demonstrated even in very young infants. However, in a study with a very large sample, Hainline et al found accommodation in infants younger than 2 months of age to be like that of either Haynes et al. or Banks et al. for near targets. Thus, limitations in sample size have obscured the results of the earlier investigators. Accurate accommodation to far targets was observed after 2 months of age, confirming Braddick et al finding. Only tonic accommodation did not appear to exhibit an early developmental trend": it was the same (approximately 1.40 D) in infants and young adults. Accommodative amplitude in preterm infants as assessed by dynamic retinoscopy can be considerable, even greater than 8.00 D. Finally, accommodative dynamics in response to steps of blur input appear to have adult like velocities by the age of 3 months." With regard to vergence accommodation, Bobier et al have demonstrated this function to be present in infants 3 to 6 months of age (50). It develops concurrently with both blur-driven accommodation and fusional vergence, thus allowing the normal array of binocular vision interactions to develop, or problem areas to become manifest (e.g., strabismus due to an abnormally high
accommodative convergence/accommodation ([AC/A ratio]). There have been no carefully controlled studies of accommodation in young children between the ages of 1 and 4.5 years. Children at these ages are difficult to assess properly because it is not easy to ensure that one has their full attention, that they understand the test procedures and criteria, and that they exert maximal effort for measurement of accommodative amplitude and facility. However, it should be possible to obtain reasonable estimates of accommodative accuracy and sustaining ability by using dynamic retinoscopy with targets of high attentional value, for example in a game-like environment.

Such knowledge will become especially important as clinicians begin to see more children in this age range as primary care practitioners, especially as a result of increasing governmentally mandated legislation in the United States. In one study in children ages 2 to 14 years, the amplitude of accommodation decreased with age, thus being consistent with overall age-related trends for older individuals (51). Chen and O’Leary found that the slope of the accommodative stimulus/response function remained relatively constant (0.92) and normal with age in young emmetropic children (3 to 14 years old) using objective methods. Hence, young children exhibit appropriate levels of accommodation to targets in free space.

**ACCOMMODATIVE STIMULUS:**

Accommodation may be stimulated by:

1. Placing the test object at a distance closer than infinity.
2. Minus lenses.
Methodology

ACCUMODATIVE RESPONSE:

The response of the accommodative system when the eye changes fixation from one point in space to another. It can be estimated by measuring the accommodative lag or accommodative lead (52).

ACCOMMODATIVE STATUS

LAG OF ACCOMMODATION:

The quantity by which the accommodative response of the eye is lesser than the dioptric stimulus to accommodation, as usually occur when pointing an object at near.

LEAD OF ACCOMMODATION:

The quantity by which the accommodative response of the eye is higher than the dioptric stimulus to accommodation, as occur when seeing at distance, in a few individuals.

DYNAMIC RETINOSCOPY

This method is to objectively measure the accommodative response to the accommodative stimulus presented. The accommodative response was assessed objectively using Monocular Estimation Method (MEM). The monocular estimate method is one of the types of dynamic retinoscopy. The normal accommodative response values while performing MEM were between +0.25 and +0.50 diopters (53). This procedure is performed at 40 cm with the appropriate distance correction (54). While the child fixates at the attractive toy binocularly, the retinoscopy is performed along horizontal meridian. If the examiner observes "with movement" it
indicates lag of accommodation and “against movement” indicates the lead of accommodation and they are neutralized using required lenses.

Table 3: Age-matched accommodative response in normal children

(Western population)

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haynes et al.</td>
<td>• 0–1 month: average accommodative response was 5 D for all distances</td>
</tr>
<tr>
<td>(1965)</td>
<td>• 1–2 months: some accommodative changes with distance</td>
</tr>
<tr>
<td></td>
<td>• 2–4 months: adult-like accommodation</td>
</tr>
<tr>
<td>Banks (1980)</td>
<td>• &lt;6 weeks: some accommodative changes with distance</td>
</tr>
<tr>
<td></td>
<td>• 8–9 weeks: adult-like accommodation</td>
</tr>
<tr>
<td>Braddick et al.</td>
<td>• &lt;9 days: consistent focusing at 0.75 m</td>
</tr>
<tr>
<td>(1979)</td>
<td>• 2–3 months: consistent focusing at 1.5 m in 60–70% of infants</td>
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<td></td>
<td>• 6–8 months: consistent focusing to 1.5 m in all infants</td>
</tr>
<tr>
<td>Brookman (1983)</td>
<td>• 2–12 weeks: slopes of SR curves (for STA ≤ 4 D) was 0.6</td>
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<td></td>
<td>• 12–16 weeks: increase in slope of SR curve for STA ≤ 4 D and under accommodation for STA &gt; 4 D</td>
</tr>
<tr>
<td>Howland et al.</td>
<td>• 2–9 months: slopes of SR curves ranged from 0.54 to 0.66, and no improvement with age</td>
</tr>
<tr>
<td>(1987)</td>
<td>• 10 months: appropriate direction of response, but inaccurate responses</td>
</tr>
</tbody>
</table>
2.3 STATISTICAL ANALYSIS

All the parameters were entered in to the Microsoft excel and analyzed using PSPP version-0.82 (http://www.gnn.org/software/PSPP) and SPSS Version 19. The data was compared with the age matched values collected in the normal children from the hospital based Indian population. Descriptive analysis was performed for comparing categorical variable. Chi-square test was used and p<0.05 was considered to be statistically significant. For comparing quantitative variables (visual acuity, refractive status, squint status, accommodative status) among categories, ‘t-test’, 'ANOVA’ or ‘equivalent non-parametric tests’ were used. For more than two groups, p value of <0.05 was considered to be statistically significant. There was high statistically significant difference (P =0.001) in visual acuity assessed using fixation pattern tests on comparing both the groups. There was high statistically significant difference (P =0.0005) in visual acuity assessed using Lea paddles in children with CP compared to normal children. There was high statistically significant difference (P =0.0005) in visual acuity assessed using Lea symbols in children with CP compared to normal children. There was no statistical significance as P=0.991 in the spherical refractive error while comparing both the groups. There was statistical significance as P=0.0005 in the cylindrical refractive error while comparing both the groups. Accommodative response was statistically significant with P=0.0005 while comparing both the groups.