

## Incidence of Accommodative Excess Reported at Binocular Vision Therapy clinic of a Tertiary Eye Care Centre Among School Children During Pandemic Lockdown

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### Abstract

**Purpose:** This study aimed to find out the aspects of incidence of accommodative excess among school-going children due to excessive near work during pandemic period in relation to various parameters like indoor-outdoor activity & screen time.

**Methodology:** A retrospective study was conducted among 176 individual children between 5-17 years of age reported with ocular or non-ocular asthenopic symptoms. A detailed test had performed to check various accommodative parameters like NPA, MEM, NRA, PRA, MAF, BAF, as well as vergence parameters like NPC, NFV and PFV. One monthly follow up had been performed all these necessary binocular vision assessments tests & checked the status.

**Results:** Out of 267 patients, 51 of them had accommodative excess (28.97%). It was found that 29% children with less screen exposure & 46% of children with excessive screen exposure had developed accommodative excess which became significant (fisher's exact 0.027).

The percentage of children with less indoor activity & excessive indoor activity with accommodative excess were 17% & 48% respectively (p value 0.052). Among all the Accommodation parameters, Accommodative facility (100%) becomes an excellent marker followed by poor NPA (33%), NRA/PRA (27%) & MEM (10%). Also children with long screen & indoor exposure developed with poor NRA more easily.(18% short exposure & 54% long exposure).

**Conclusion:** Children with prolonged near work & indoor activities suffered more compared to children with some outdoor activities & less screen exposure. Secondary convergence insufficiency can be there along with accommodative excess.

A proper vision therapy and appropriate counselling about the visual hygiene & environmental modifications should always be advocated to save our future shapers of this beautiful world.

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**Keywords:** Accommodative excess; Binocular vision; Near point of convergence; Near point of accommodation; Monocular estimated method; Digital stress.

## Introduction

The Dioptric power of the eyeball alters during accommodation by change in lens shape, contraction in ciliary muscle and zonular fibres resulting in a clear retinal image. However, the standard accommodative system is relatively elastic and resistant to fatigue [1-5].

Accommodative excess is where the amount of accommodation is far more compared to the normative age-related demand at a certain distance. Bakir et al reported that the average digital device usage of around  $4.8 \pm 2.8$  h and total usage  $8.65 \pm 3.74$  hours per day resulted in sleep disturbance of around 62.4% of the population, and 95.8% of the people experienced at least one symptom related to the digital device usage [6-11].

During COVID-19 Pandemic period school going children had to spend more hours on digital devices to do the school work/online classes. Hussaindeen, J R reported in her study that among south Indian school going children the Non strabismic binocular anomalies are more common and the prevalence increases with age. She also advocated that with more near visual demand in higher grades, the anomalies could significantly affect the reading efficiency of the children [9-17].

Accommodative and vergence dysfunction are the most common vision disorders in paediatric population with a prevalence of 30% and patients with these dysfunctions usually have symptoms that could affect academic results. Sometimes variations in the sphere values while performing retinoscopy could be clues for

accommodative dysfunctions [8]. Accommodation excess is a rare condition characterized by sudden and involuntary sustained development of myopia without any accommodative stimulus and its usually functional in origin which may attribute to psychogenic factors triggered by anxiety, depression, emotional distress, or malingering [18].

Studies conducted by Wajuihian & Hansraj on black students in South Africa in 2016 & 2019 consistently reported AE as 2.8% [19-21].

Another study by Porcar et al in 2018 found Convergence excess as the most frequent, followed by fusional vergence dysfunction within the non-strabismus dysfunctions and CI and accommodative excess as the most common, followed by accommodative insufficiency in the accommodative dysfunctions.

Accommodative Excess occurs when a person uses the particular distance more than the normal. It may cause tiredness, strain dizziness headache, trouble concentrating and many other related symptoms while performing near work. Excessive use of digital devices or prolonged hours working on screen may further add to the problem in school going children and IT Sector people.

Excessive accommodation is commonly association with excessive convergence. Also, improper spectacle prescription and uncorrected refractive errors with improper fitting or few of the drugs like carbonic anhydrase, morphine sulphonamide may cause ciliary spasm with excessive accommodation or even secondary to

convergence insufficiency. PFV (Positive fusional Vergence) and NPC (Near point of convergence) reduces in convergence insufficiency, so the patient induces excessive accommodation to stimulate accommodative convergence to overcome reduced PFV.

Accommodative Excess induces artificial myopia that is defined as temporary shift in eye towards myopia as a result of accommodative excess or Spasm. Appropriate Binocular vision therapy can alter the required dynamics of an accommodative facility & near accommodative response [3].

For an Optometrists to understand the reasons for symptoms and design an effective treatment program, Mitchell Scheiman stated that optometrists must perform a comprehensive assessment of accommodation and binocular vision by using an appropriate testing, combined with attention to the environmental factors associated with VDT use to meet the needs of symptomatic VDT (visual display terminal) users [12].

## Methods

### Study Design

To carry out the research objectives, retrospectively the data of school going children has been reviewed between 5-17 years seen at Binocular vision therapy clinic of Dr. Shroff's Charity Eye Hospital from Mach'20 to Feb'21, when school were closed due to COVID-19 pandemic and children were majorly forced to do academic & leisure activities over digital screen. To study the impact of digital screen usage on the binocular parameters & its subsequent result of asthenopic symptoms during the COVID-19 pandemic time had been opted.

## Subjects

51 non-strabismic subjects were included primarily who reported to have spent at least two hours per day screen time while studying. The inclusion criteria considered the best corrected visual acuity of more than or equal to 6/9 with Snellen chart monocularly. Refraction included the dry subjective refraction findings along with cycloplegic refraction. The near vision should be 6/6 or N6 in near reading or reduced Snellen chart respectively. Previous intraocular/strabismus surgery, amblyopia, eccentric fixation, Duane retraction syndrome, ocular or head trauma and any systemic or eye pathology like cataract, glaucoma, scars, retinal anomalies etc were excluded. Degree of Refractive error was not limited for inclusion. Complete binocular vision assessment was conducted with appropriate refractive correction for patients. The study complied with the ethical requirements of Institutional Review Board of our Institute and followed the tenets of the declaration of Helsinki protocol. Informed consent was taken from all subjects by explaining the nature and possible consequences of the study.

### Institutional Protocol for Clinical history and examination

According to the protocol of Binocular Vision Therapy clinic the detailed symptoms survey questionnaire is followed for each patient (CITT symptom Survey form [13,22,23] and patients are asked specifically about their ocular symptoms with graded intensity of eye symptoms like: 4 (severe), 3 (moderate), 2 (mild), 1 (slight) and 0 (none), thus allowing us to obtain the mean impact (0-to-4 scale) of each symptom [9-11,14-18,22]. Within the BVT clinic patients detailed & relevant clinical

history especially screen time usage, ergonomic set up, principle asthenopic symptoms & outdoor activities & other visual hygiene are captured.

On Examination Monocular and binocular visual acuity is measured under photopic conditions at a distance of 6 meters with the Snellen chart & at a distance of 33 cm with reduced Snellen or near reading booklet for distance & near respectively.

The detailed eye examination is completed in two sessions. The preliminary tests include visual acuity, refraction by adequate fogging, binocular balancing of accommodation and duochrome test, Cover test at a distance and near, ocular motility, pupil examination and the evaluation of ocular health (direct ophthalmoscopy, Slit Lamp bio microscopy) followed cycloplegic evaluation with age appropriate cycloplegic drugs if required.

Patients undergo detailed binocular vision assessment including Near point of convergence, ocular motility, Sensory fusion (Worth Four-Dot test) at distance & near, Motor Fusion (Prism Vergence) and Accommodative dysfunctions (MEM, NPA, NRA, PRA & Facility).

### **Protocol for accommodative and binocular vision examination at BVT Clinic**

With appropriate refractive correction for distance in place, accommodative & vergence status were checked. Near Point of Accommodation was assessed with Royal Air Force (RAF) rule by push-up method using accommodative targets monocularly & binocularly. The best achievable near target was moved slowly towards the face until the patient noticed the first sustained blur.

The distance from ruler was read and expressed in centimetre which helped in calculating the Accommodative Amplitude which is defined as the reciprocal of Near Point of Accommodation and expressed in dioptries.

Accommodative facility enables to fine & fast switching of accommodation to its maximum to minimum limits and the test determines how easily and smoothly one can do. It was measured in cycles per minute (CPM) with the help of +/-2.00 lens pair mounted in a double-sided lens holder. Procedure was repeatedly done over each eye and the time needed to see the target clearly was documented. Relative accommodation was measured for the maximum ability to stimulate or relax the accommodation while maintaining clear BSV.

For Negative Relative Accommodation (NRA) a pair of plus lenses in +0.25D increments were placed in front of both eyes, until patient reports first sustained blur and documented the maximum lenses added to reach this point as NRA value. High NRA values (>+2.5D) was considered as evidence of uncorrected hyperopia or latent hyperopia. For Positive Relative Accommodation (PRA) a pair of minus lenses in -0.25D increments were placed in front of both eyes, until patient reports first blur and documented the maximum lenses added to reach this point as PRA value.

High PRA (>-3.5D) was considered as disorder of accommodative excess and Accommodative insufficiency was seen with PRA values <-1.50D. With appropriate refractive correction for distance in place, an accommodative target was viewed.

Near Point of Convergence was measured using the RAF ruler and push-up method. A dot and a line target size of 6/6 to 6/9 on RAF rule was moved towards the observer. Nearest point when the patient lost his/her fixation or developed diplopia was defined as the near point of convergence and expressed in centimetres. In Dynamic Retinoscopy Monocular Estimation Method (MEM) was used to determine the status of accommodative lead or any lag.

Accommodative lag was recorded where there was a less accommodation supply compared to what was desired/demanded & accommodative lead when there was more accommodation compared to demand to see things clearly. Patients were asked to read the letters/line of an accommodative target at 40 centimetre.

Retinoscopy was performed from the target plane of 40 cm & depending on the reflex movement plus or minus lens were needed to neutralize the reflex. Minus lens denoted lead of accommodation & plus lenses to lag of accommodation. +0.25 to +0.75 regarded as normal lag. This was also done with the help of RAF rules using a dot and a line target. Dynamic Retinoscopy (MEM): Monocular estimation methods were used to determine the status of Dynamic retinoscopy to check the accommodative lead or any lag.

Accommodative lag was something where there was a less accommodation supply compared to what was desired/demanded & accommodative lead was something in which there was more accommodation compared to demand to see things clearly. An accommodative target was placed at 40 centimetre & asked patients to read the letters /lines, retinoscopy was performed from the target plane that means 40 cm &

depending on the reflex movement plus or minus lens were needed to neutralize the reflex.

Minus lens denotes lead of accommodation & plus lenses to lag of accommodation. +0.25 to +0.75 regarded as normal lag.

### **Follow ups & Review**

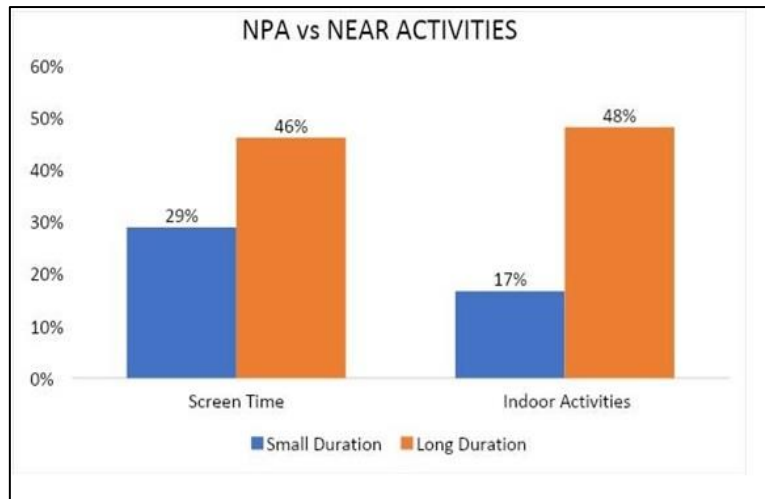
Appropriate vision therapy was advised to each patient & asked to follow up monthly. At monthly follow ups, all the binocular vision assessments tests were performed & checked the status as per the clinical protocol.

### **Results**

In the retrospective study among a total of 267 patients, 51 of them (18 males & 33 females) were eligible for the study with mean age of  $12 \pm 4$  years. These children had a mean screen time of  $4.4 \pm 3.5$  hours mostly over mobiles, tablets, laptop, televisions.

The incidence of accommodative excess was found to be 19.10% among these study group at our tertiary eye care center between December 2019 & December 2020. 6 hours & 4 hours had been considered as the cut off or borderline value for the consideration of long time & short time screen exposure.

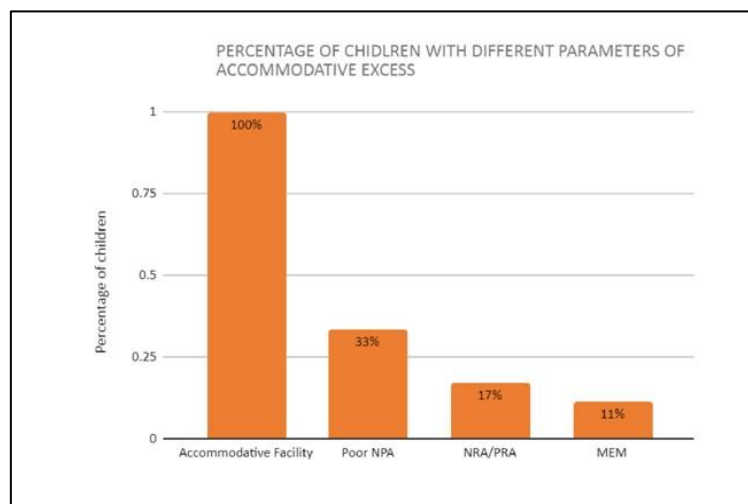
It was found that children with smaller duration of indoor activity had less impact in affecting the NPA of 17% and those with less screen time as 29%. Children with long duration of indoor activity & screen time had poorer NPA 48% & 46% respectively, which is although statistically not significant as per Fisher's Exact test (p value 0.3148) for screen time & significant statistically for indoor activities (p value 0.02091) as depicted in Figure 1.



**Figure 1:** Table for Poor NPA versus Near activities including both Screen time & Indoor activity.

Out of all binocular parameters, accommodative facility (100%) proved to be the most appropriate marker to diagnose accommodative excess followed by poor NPA (33%), NRA/PRA (17%), MEM (11%) as shown in figure 2.

Children with rigorous indoor activity were found to develop with lead of accommodation in 89% of total children which was statistically significant (p value 0.05246) as per the (Fisher's Exact Test).

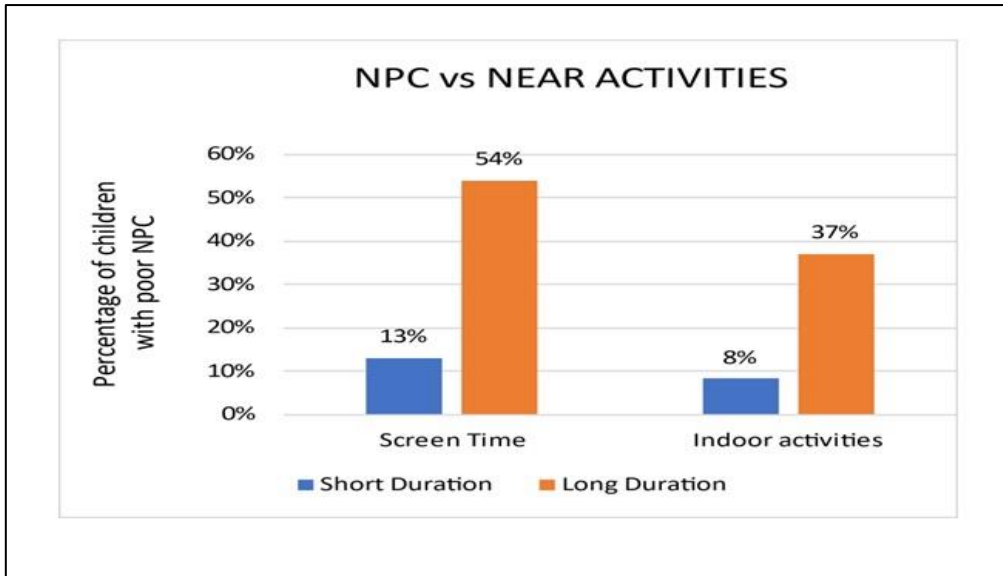


**Figure 2:** Table for Parameters of accommodative excess versus percentage of children.

It has also been seen that 17 of the 51 children (33.33%) had developed with convergence insufficiency secondary to accommodative excess.

activity as shown in Figure 3. The percentage of children with poor NPC varied from 13% to 54% & 8% to 37% between the short duration & long duration of screen time & indoor activity respectively which was statistically significant (p value 0.006063 & 0.02153 respectively for screen time & indoor activity).

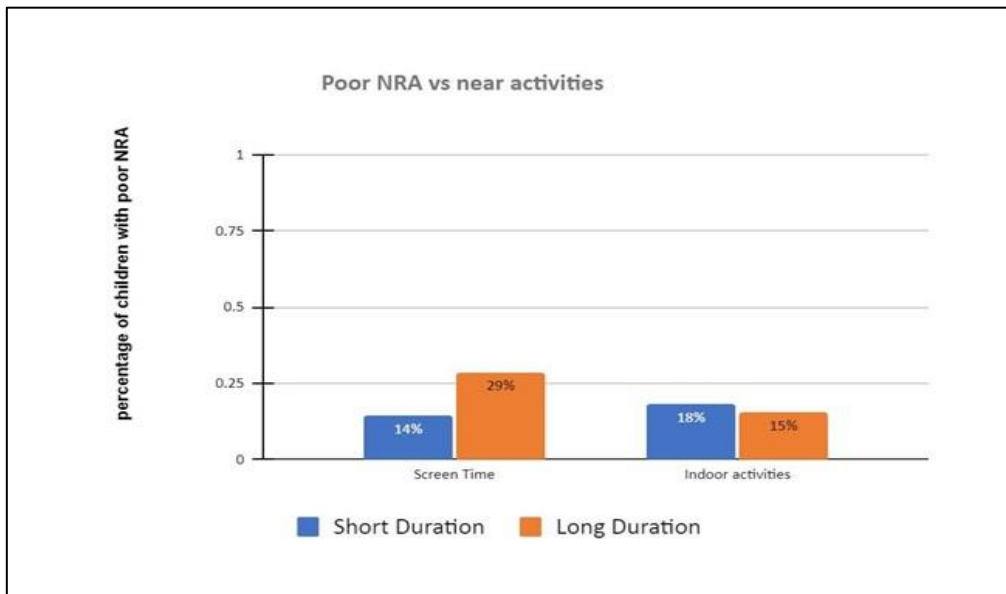
There was a significant impact over these children with the effect of unnecessary usage of digital screens & increased indoor



**Figure 3:** Percentage of children with poor NPC versus Near activities including both Screen time & Indoor activities.

Also, it was evident that most children with poor NRA were attributed to longer duration of digital screen (29%) exposure as

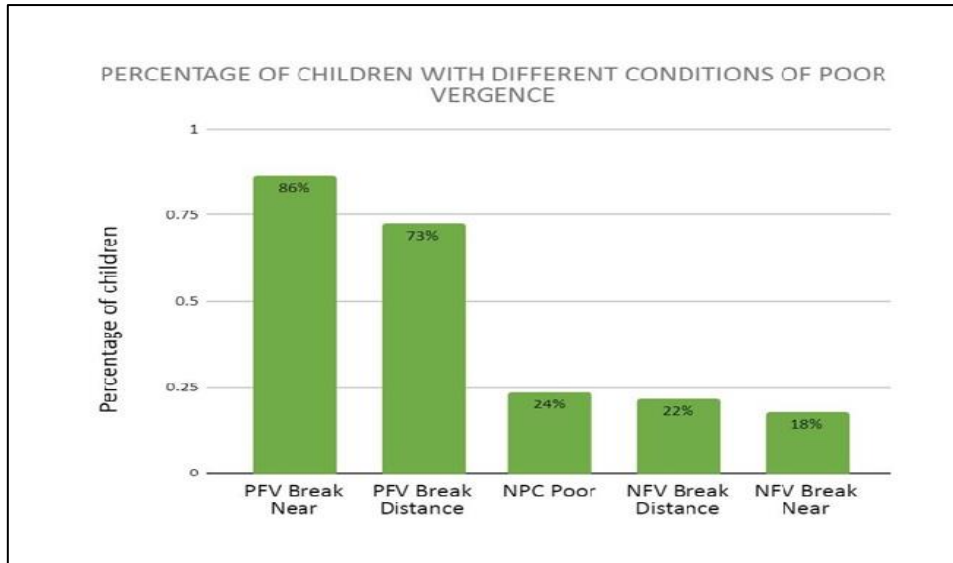
depicted in Figure 4 which is statistically significant ( $p$  value 0.02728) as per the Fisher's exact calculation.



**Figure 4:** Table for Percentage of children with poor NRA versus exposure of screen time & indoor activities.

It was very much noticeable that vergence parameters both for distance & near indicated more towards convergence anomaly. The best marker for the convergence insufficiency was proved to be

Near PFV break point (86%) followed by Distance PFV break point (73%), Poor NPC (24%), Distance NFV break (22%) & Near NFV break (18%) as shown in Figure 5.



**Figure 5:** Table for percentage of children versus Various parameters or vergence at distance & Near.

Dysfunction	Abnormal Clinical Sign
Accommodative Insufficiency	Accommodative Amplitude (Push-up method): 2 D below Hofstetter's calculation for minimum age-appropriate amplitude: (D) $15-0.25 \times \text{age}$ in year. MAF < 6 cpm (difficulty or failure clearing with $\pm 2$ D Flipper); MEM > 0.75 D.
Accommodative excess	MAF < 6 cpm (difficulty or failure clearing with +2 D); or BAF < 3 cpm (difficulty or failure clearing with $\pm 2$ D); MEM < 0.25 D; NRA < 1.5 D
Accommodative infacility	MAF < 6 cpm (difficulty or failure clearing with $\pm 2$ D); BAF < 3 cpm (difficulty or failure clearing with $\pm 2$ D); NRA < 1.5 D and PRA < 1.25 D.
Convergence insufficiency	Exophoria, near > 6 $\Delta$ base-in; PFV, near (break) < 15 $\Delta$ base-out; NPC (break) > 7.5 cm or NRA < 1.5 D
Convergence excess	Esophoria, near $\geq 0.5 \Delta$ base-out; NFV, near (break) < 17 $\Delta$ base-in; VF < 12 cpm (difficulty or failure with 3 $\Delta$ base-in) or PRA < 1.25 D.
Fusional vergence dysfunction	Normal phoria, near and at a distance; PFV, near (break) < 15 $\Delta$ base-out and NFV, near (break) < 17 $\Delta$ base-in; VF < 12 cpm (difficulty or failure with 3 $\Delta$ base-in and 12 $\Delta$ base-out).
Basic esophoria	Esophoria of approximately equal magnitude, near and at a distance; NFV, at a distance (break) < 4 $\Delta$ base-in; NFV, near (break) < 17 $\Delta$ base-in.
Basic Exophoria	Exophoria of approximately equal magnitude, near and at a distance; PFV, at a distance (break) < 11 $\Delta$ base-out; PFV, near (break) < 15 $\Delta$ base-out.

**Table 1:** Clinical signs used for the diagnosis of accommodative and non-strabismic binocular dysfunctions [17]. AA- Accommodative Amplitudes, NPA-Near Point of Accommodation, NPC-Near Point of Convergence, MEM-Monocular Estimation Method (for Accommodative Lead or Lag), NRA-Negative Relative Accommodation, PRA-Positive Relative Accommodation, PFV-Positive Fusional Vergence, NFV-Negative Fusional Vergence, MAF-Monocular Accommodative Facility, BAF-Binocular Accommodative Facility.



## Discussion

The knowledge about the neuronal mechanism of accommodation is still very limited. Young children are known to have a high amplitude of accommodation. Accommodation has a strong correlation with the increment of age; so, calculation of amplitude of accommodation needs to be age appropriate [24,25]. Although there are a variety of approaches to the diagnosis of binocular vision anomalies, the results were therefore analysed in different ways. Accommodation & convergence are synergistically linked together. Pandemic had left the children with no option but to be very much dependable on digital screens & indoor activities. To continue education & other academic work children used digital screens and indoor near tasks for longer hours. It is known that the first clue for the initiation of accommodation is blur perception. And the intense near work has put the children into a state of sustained blur with asthenopic symptoms where the accommodation is malfunctioned. Cycloplegic refraction is indicated as uncorrected hyperopia exert more accommodation than emmetropes or myopes [26]. After giving appropriate refractive correction the binocular vision parameters need to be checked.

In this study population the children with higher hours of Screen time & indoor activities had suffered more with asthenopic symptoms than the children with less indoor & near screen time activity. Nearly 22 % of the total children who came to our BVT clinic during the pandemic period had been symptomatic & diagnosed with accommodative excess. Children with more or less outdoor activities did not have more of the asthenopic symptoms like eye strain,

headache (frontal & overall) infrequent blurring of letters, neck ache, running of letters, increased blink rate compared to children with long hours of screen exposure. Females were affected more than males & older teens than younger or early teens. It was believed that the study population would have been more if there was easy accessibility & transport & awareness among the population. Out of all the binocular vision parameters, accommodative facility was found to be the best appropriate marker to diagnose accommodative excess followed by poor NPA, NRA & MEM. Children with poor NPA were found to have spent more hours with screen or indoor activities. As accommodation is actually very much connected with convergence; children with poor NPA had developed poor convergence secondary to accommodative excess, which was 33.33%. Poor NRA became the second-best indicator after the NPA to detect accommodative excess which contributes around 17%. The least appropriate marker was MEM value which was attributed around 11% among the study population. Children with indoor activities had more proneness to develop accommodative excess than the children with increased screen exposure. Children with accommodative excess associated with convergence insufficiency had suffered the most with the ocular & non-ocular symptoms than the children with only accommodative excess. An appropriate office-based therapy followed by home based therapy was indicated in this study & close follow ups is a must to intervene & introduce any additional therapy for the betterment of binocular vision parameters. All the questionnaire data is so subjective because the hours of screen usage time was gathered mostly from the patient's

attendant; which was most of the time the child's own parents. So, the study data may be richer if consider the obtained data as the most exact data. So, to bring back the smile to a child's face an appropriate history along with age appropriate diagnosis is very necessary to detect & manage these patients very efficiently.

Normally accommodative excess is found to be a key component in the majority cases with convergence excess but this study proved to be the reason for secondary convergence insufficiency caused by the effect of excess of accommodation.

## Conclusion

The study fills a gap in the literature in providing data on incidence of accommodative excess during pandemic times predominantly among school goers. Children with short duration in both indoor activity & screen time had less likely to develop accommodative excess compared to children with long duration. The

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increased incidence of accommodative excess in school going children due to increase near activity on digital screens & forceful indoor activity. These unexpected binocular vision anomalies have made a child's life more bizarre and troublesome & lower down their performance. Convergence insufficiency secondary to accommodative excess had also been found in children which can again cause several other additive asthenopic symptoms.

## Conflict of interest

No conflicts of interests as such.

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