

EFFECT OF ORTHOPTIC EXERCISES AND DIATERY SUPPLEMENTS FOR THE RELIEF OF ASTHENOPIC SYMPTOMS IN PATIENTS WITH CONVERGENCE INSUFFICIENCY

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ABSTRACT

Background: Convergence Insufficiency is characterized by a decreased ability to converge the eyes and maintain binocular fusion while focusing on a near target. The most common treatment for convergence insufficiency is orthoptic exercises.

Aim: Aim of this study was to assess and compare the effect of orthoptic exercises with dietary supplements for the relief of asthenopic symptoms in patients with convergence insufficiency.

Methodology: This Quasi Experimental study was conducted in THQ Karor Lal Eason, District Layyah on the patients presenting with convergence insufficiency caused by muscle imbalance. Total 90 patients were randomly divided into 3 groups of 30 patients each, by non-Probability purposive sampling technique. The study duration was September 2022 to May 2023. Patients have the 18.5- 24.5 BMI range were included. Orthoptic exercise (brock string test), dietary supplement (vitamin C) and combination of both were prescribed to group 1, 2 and group 3 respectively. Follow ups were performed on 2nd and 4th week of the study. Data was analyzed using IBM SPSS. Descriptive statistics and one way ANOVA were applied.

Results: The mean values of RAF measurements at baseline were 14.7 ± 0.9 , 14.9 ± 0.9 and 15.7 ± 1.41 in group 1, 2 and 3, respectively. The mean values of RAF measurements at first follow up were 12.4 ± 0.4 , 14.0 ± 0.9 and 11.2 ± 0.8 of group 1, 2 and 3 respectively. The mean values of RAF measurements at 2nd follow up were 10.0 ± 0.0 , 142.6 ± 0.6 and 6.8 ± 0.7 in group 1, 2 and 3 respectively. The results showed significance results which were $p=0.00$ at the 1st and 2nd follow up.

Conclusion: It was concluded that orthoptic exercise and combination of orthoptic exercise and dietary supplements is a best treatment options for the relieving of asthenopic symptoms in patients with convergence insufficiency as compared to dietary supplements only.

Key words: Asthenopia, Convergence Insufficiency, Dietary Supplement, Double Vision

INTRODUCTION

Asthenopic symptoms, such as blurred vision, diplopia, difficulty doing near work, eye soreness, headache, redness, and eyestrain, are frequently caused by convergence insufficiency. Symptoms of asthenopia are quite widespread: The most common health issues affecting computer users are eye-related, caused by accommodation issues or binocular vision issues like convergence insufficiency that don't manifest as signs while executing less demanding visual tasks. The two primary categories of asthenopia are: muscular asthenopia and refractive asthenopia. Glasses can help with asthenopia brought on by refractive errors and may also help with accommodation. Convergence and accommodative training may reduce muscular asthenopia, which is linked to accommodative abnormalities and convergence insufficiency, as well as to correct refractive and prismatic correction (1).

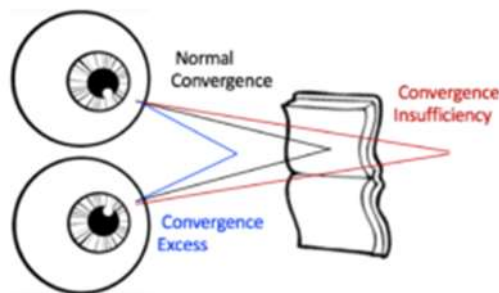


Figure 1.1: Convergence Insufficiency

A large number of school children complained of asthenopia. In order to prevent diplopia, a child may close one eye when reading and writing. While individuals are sleeping or not using their close-up vision, the symptoms lessen or vanish. The patient could experience no symptoms on the weekends and throughout holidays. Refractive asthenopia and muscular asthenopia are the two

basic categories of asthenopia. Uncorrected refractive defects such as hypermetropia, myopia, astigmatism, and anisometropia lead to the first kind. There is convergence and accommodation deficiency in the second form of latent strabismus. A thorough evaluation of refraction, sensory fusion, binocular vision, and all accommodative functions are required for a correct diagnosis. With the right glasses, refractive error-related asthenopia can be reduced. Most of the time, convergence and accommodative therapy can reduce asthenopia brought on by accommodative abnormalities and convergence insufficiency. When glasses are worn, asthenopia symptoms are frequently relieved and the accommodative capacity often improves. The relationship among convergence insufficiency and the asthenopic symptoms, myopia, astigmatism, hypermetropia and near point of accommodation has been discussed in various research on asthenopia in adults and children, independently (2).

The diagnosis of CI in optometric practice is typically, although not always, based on assessed NPC using the push-up technique with the degree of severity of the signs. The most common way to describe convergence insufficiency is as a syndrome that manifests as exophoria that is stronger at close range than at a distance, remote near convergence point, diminished or nonexistent fusional convergence, particularly at close range, and normal prism divergence. Patients with orthophoria or even esophoria at near may exhibit convergence insufficiency, albeit this is less frequent. Low AC: A ratios and inadequate accommodative responses, such as the ineffective use of accommodative convergence and accommodative insufficiency, are additional clinical findings connected to CI (3).

When maximal convergence is used, the point in space that is exactly in towards the patient's face in the median plane is referred to as the near point of convergence. This location is defined by the junction of the lines of sight. It is a crucial clinical measurement that is frequently used in optometric eye exams. The NPC is determined by determining whether event occurs first: the patient's report of a doubled target or the examiner's observation of one eye losing fixation and turning outward. The distance that exists from this point to the plane of the centres of rotation of the two eyes is calculated to obtain the numerical value assigned to the NPC. In actuality, however, the subject's head's midpoint above the two eyes is where the measurement is taken. Cited extended NPC as a particularly reliable CI discovery. 93.8% of optometrists who participated in the survey reported using NPC to make the diagnosis, and CI was frequently diagnosed exclusively on the

basis of NPC. NPC is generally accepted to have normal values between 8 and 10 cm. NPC in children up to the sixth grade is often less than 6 cm, according to several recent studies (4).

Children in school-age suffer from convergence insufficiency (CI), a common eyesight condition. In comparison to children who have normal binocular vision, children having convergence insufficiency exhibit these symptoms much more frequently, as determined by the symptoms survey of convergence insufficiency (CISS). When compared to parents of children with CI with parents of children with normal binocular vision, then children with convergence insufficiency reported significantly more undesirable school behaviors on the Academic Behavior Survey (ABS), in addition to the symptoms that children with CI reported on the CISS. Parents of children having CI are far more likely to report difficulties with schoolwork completion, avoidance of reading and studying, and lack of attention or distraction during reading than those of children who was having normal binocular vision. Moreover, parent of children with convergence insufficiency report being more concerned about their child's performance in school as compared to parents of children having normal binocular vision (5, 6).

Previous studies, however, did not look into whether reductions in parental reports of negative school behaviors and parental anxiety paralleled changes in child reported symptoms. The determination of diseases that depend on parent observations of children's behaviors may be affected by parental reports of negative behaviors connected to school work in children with symptomatic convergence insufficiency. For instance, new research has raised the possibility that Attention Deficit Hyperactivity Disorder (ADHD) and convergence insufficiency may be related (7).

The behaviors that are typically described in the distracted form of ADHD (For example, not finishing tasks and having trouble focusing in class) are comparable to a number of symptoms regularly reported by children with CI, such as difficulty maintaining attention when reading or reading slowly. After that convergence insufficiency with symptoms in school going children was successfully treated, the ABS was used in this study to find out views of parents on the degree with negative behaviors displayed by their children when reading or completing schoolwork and in general their concern regarding the academic performance of child. A decrease in the occurrence of negative academic behaviors and parental worry about reading and schoolwork, as indicated by parents, were associated with a successful or better outcome following CI treatment (8).

Clinically defined by near exophoria, a greater exophoric tonic position at far than at near, convergence at the near point, and lower fusional amplitudes, this sensory motor anomaly is characterized by a difficulty in determining converge or sustain convergence at close range. Physiologically, convergence and accommodation are linked. Through this linkage, the eyes also accommodate during accommodative convergence, measured by the AC/A ratio, and accommodate during convergence accommodation, measured by the C/AC ratio. Parents of children having convergence insufficiency noted a considerably higher degree of negative academic behaviors and stress over academic success as compared to children with normal binocular vision, (9, 10).

The specific negative academic behaviors that parents have noted include struggles with schoolwork completion, aversion to reading and studying, and lack of attention when reading. In comparison to sham and home-based therapies, recent randomized Clinical studies have discovered that (OBVAT) office based vergence accommodative therapy is a particularly successful therapy for lowering visual, somatic, and performance based signs and reducing clinical symptoms of convergence insufficiency in children. Additionally, during therapy for convergence insufficiency with symptoms in school going children, improved and effective results were linked to a general decline in the incidence of negative academic behaviors and parental worry about reading and homework. The determination of diseases that depend on parent's perceptions of children's behaviors or emotional difficulties may be affected by parental reports of negative behaviors connected to schooling in children having symptomatic CI. For instance, current research points to a potential association between ADHD and CI (11).

Additionally, during therapy for convergence insufficiency with symptoms in school aged children, successful and better results were relate to a general decline in the incidence of negative academic behaviors and parental anxiety about reading and homework. For instance, new research has hinted to a potential connection between CI and ADHD. Convergence insufficiency is a disorder where it is challenging for the eyes to work together to focus on near things that are closer than 10 cm from the nose. Symptoms of inadequate convergence frequently encountered. Eyestrain or Frontal headaches brought on by close work; Close-up job-related blurriness and intermittent double vision. Orthoptic exercise is a therapy to treat convergence insufficiency. A variety of orthoptic exercises are available, and they are all designed to enhance how well the eyes operate together.

Successful completion of every stage of treatment is anticipated to produce long-lasting effects and symptom-free patients. Some individuals, meanwhile, might need to repeat the workouts in subsequent years. If carried out exactly as directed, the workouts are very effective. But they are dependent on, Proper exercise technique, frequent and frequent exercise (three or four times per day), which calls for resting the eyes thereafter and the necessity to wear the proper eyewear, if necessary (12).



Figure 1.2: orthoptic exercise

Smooth convergence is also a treatment option for convergence insufficiency. Hold the wooden spatula at arm's length, slightly below eye level, and attach an inadequately detailed target on it. Bring the target gently closer your nose while attempting to maintain a clear, single image. When the image breaks into two, push the spatula away slightly to reunite the images. Next, slowly move the target back towards your nose while attempting to maintain a single image. When you are close enough, hold the image still while counting slowly from 10 to one. Jump convergence is an exercise which used now a days. Start by looking at the distant target on the spatula, which should be kept single, then look at the near target on the spatula, which should be kept single. If the near target is single, then turn your attention back to the distant target while bringing the near target slightly towards your face and focusing on it once more. Repeat for more near positions unless you are unable to maintain the single near target. Dot Card therapy, Hold the dot card pointing slightly downwards on the tip of the nose. Focus on the farthest point for a slow count of 5 (one hand at the top and one at the bottom of the card). Slowly shift your attention to the next area and hold it there for another slow count of 5. As you move towards the nose, test each area in turn. Keep your attention focused for a slow counting till 5. If you encounter an area that you are unable to keep single, concentrate intently on it to try to return it to single vision. If it doesn't, go back to the preceding spot and try the closer one again. Keep in mind that any area you are focusing on should

appear single, while everything else—both in front of and behind—will appear double. This is typical (12).

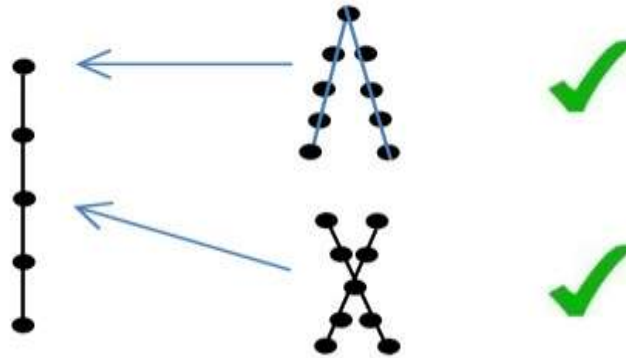


Figure 1.3: Dot Card Therapy

Stereograms Cats, buckets, and circles are just a few examples of the many stereograms that exist. They all operate by practicing distinct concentration and convergence. It takes some practice to become proficient at them. Hold the stereogram at arm's length, place a pen in front of the card, focus on the tip of the pen, and slowly move the pen in your direction while keeping an eye on the background stereograms. The background stereograms must each show up to separate apart as the pen moves. The two center images should seem to overlap when the pen is placed around halfway towards your nose, creating a full third image in the midst of the original two. Hold the entire third image in position while slowly counting to ten. The stereogram images may initially appear to be quite blurry, but with practice they will get clearer. Things to keep in mind, Wear the proper eyewear (if you use them), Exercise three to four times per day, Success comes from doing small things frequently. Try to keep the exercises to no more than two to three minutes each time, and then relax your eyes. This can be accomplished by closing your eyes for a short period of time or gazing out the window into the far horizon (12).



Figure 1.4: stereogram

The Brock String is used to teach patients how to see with both of their eyes open at once. The individual should perceive one bead that has two short strings heading towards it and two larger strings departing it when they glance at the first bead. The patient should observe a huge "X" formed by two strings entering the bead and two strings exiting it. On every of the white strings you see extending from or entering that fixation bead, the beads that are not being focused on will emerge in the distance (12).

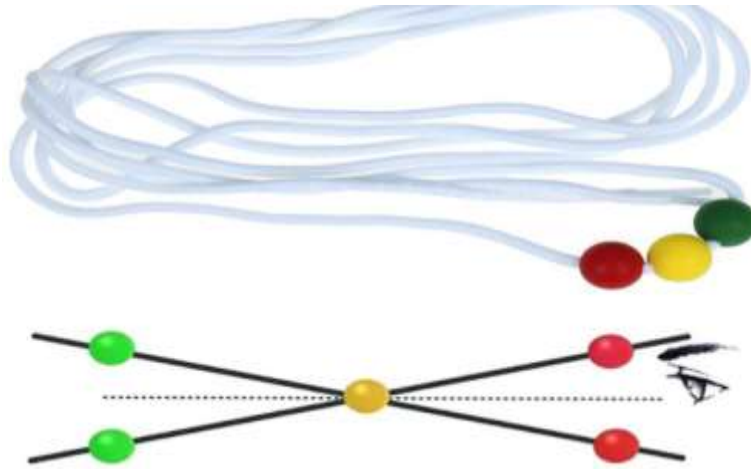


Figure 1.5: Brock String Test

Computer use and reading have become a necessity in our daily life. An individual's standard quality of life may be greatly affected by medical disorders that impair near vision. These challenges of near difficulties impact individuals across all age groups, from children who are learning to read, to adults who are using computers, to senior patients who are receiving advanced intraocular lenses with the hope of achieving clear vision for close-up tasks. In order to properly assess patients with near problems with near vision, practitioners must be aware of these symptoms and be able to identify them. Convergence insufficiency is one generally prevalent disease that greatly impairs near vision. Diplopia, asthenopia, hazy vision, and headaches are typical symptoms. Additionally, it may result in nausea, motion sickness, and vertigo. Unfortunately, not all eye care practitioners perform routine screenings for convergence insufficiency. The fact that the diagnostic criteria and examination techniques differ in the research as well as practice is one of the issues with identifying and diagnosing convergence insufficiency. As a consequence, some patients may

obtain a wrong diagnosis, a diagnosis that is given too late, or no diagnosis at all, and they may continue to experience their symptoms. This may result in higher healthcare costs for doctor visits, diagnostic procedures, and even unneeded or unrelated surgery. The methods of screening, the diagnosis, and the most recent treatments for convergence insufficiency are the main topics of this review. Convergence insufficiency is a condition that eye care providers must be familiar with in order to avoid missing one of the main causes of headaches and near complaints (13).

The presence of a distant near point of convergence or a diminished positive fusional vergence, along with exophoria that is stronger at close range than at a distance, are signs of convergence insufficiency. The treatment options for convergence insufficiency involve a range of non-surgical approaches. These include the use of reading glasses with base-in prisms, performing convergence exercises at home (commonly known as pencil push-ups), engaging in vision therapy or orthoptics exercises at home, as well as undergoing outpatient or office-based vision therapy or orthoptics sessions, particularly in the United States. Convergence insufficiency may be treated with surgery, but it is rarely performed due to the procedure's relative invasiveness and potential consequences (14).

Digital asthenopia, often known as eye tiredness or strain, continues to be the most prevalent visual ailment, followed by headaches, ocular pain, and blurred or double vision. Accommodative and vergence-related stress as a result of continuous fixation or uncorrected refractive error at close viewing distances might be blamed for difficulty focusing between working distances. Using handheld devices like smartphones and tablets to read text creates more strain on the ocular muscles than reading from printed text, which causes a recession in the convergence at the near point and a loss in accommodative function. When a visual task's cognitive demands are too great for a person to comfortably handle, asthenopic symptoms frequently appear gradually. For instance, headaches and eye pain brought on by excessive squinting and glare might result from the ocular demands of prolonged computer use (15-17).

Both the number of people using computers and the number of individuals reporting asthenopia symptoms are rising quickly. In order for these people to live peacefully, the symptoms of asthenopia must be relieved. According to certain reports, some food elements can significantly improve eye health. Fish oil contains two fatty acids called Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) that are frequently cited in this context. The main polyunsaturated

fatty acid in retinal rod outer segments is DHA. According to some epidemiological research, DHA may help prevent dry eye syndrome (DES) and age-related macular degeneration. Consumption of EPA has been demonstrated to shield mice from choroidal neovascularization and associated inflammation. Additionally, bilberry's anthocyanins and lutein are well-known for being powerful components for preserving eye health. Strong antioxidants, anthocyanins may speed up rhodopsin regeneration. Selectively accumulating in the retina, lutein is especially abundant in the macular area. Additionally, lutein serves as an antioxidant. They predicted that patients with asthenopia brought on by a variety of reasons would benefit greatly from taking a supplement containing a mixture of these components because each ingredient's action site appears to be different. In this investigation, they conducted a randomised, parallel-group, double-blind, and placebo-controlled trial to determine if daily consumption of a nutritional supplement comprising these substances was effective in reducing the symptoms of asthenopia in humans. We also looked at how these substances affected the psychological well-being of patients for the reason that asthenopia symptoms have been suggested to contribute to mental weariness. Additionally, we looked at the supplement's safety (18).

With the increasing importance of computers and other mobile electronic gadgets in our daily lives, digital eye strain has unfortunately become an unintended side effect. The complicated aetiology linked with digital eye strain must be taken into account when developing a complete management strategy. In recent years, it has become more and more clear how important nutrition is for encouraging healthy visual function and the potential repercussions of inadequate nutritional consumption. As an alternative, recent research provides encouraging evidence that complementary nutraceutical approaches may provide further systemic health and ocular advantages for people who have digital eye strain (19).

MATERIALS AND METHODS

A Quasi Experimental study design was conducted. This study was conducted at Tehsil Head Quarter Karor district Layyah. The duration of study was from September 2022 to May 2023. The Sample size of this study was 180 eyes of 90 patients. Patients were divided into 3 groups and the orthoptic exercise was prescribed to 30 patients, dietary supplements was prescribed to 30 patients and combination of orthoptic exercises and dietary supplements was prescribed to 30 patients. The Non –Probability purposive sampling technique was used in this study. This research was carried

out by self-structured Proforma and questionnaire. These instruments will be used in this research study

- Optic Ophthalmic Equipment Royal air force ruler (RAF)
- Log MAR chart(Brien Holden)
- Schirmer Tear Test Strips(Surgitech Innovation)

Inclusion criteria:

- Emmetropes patients who have asthenopic symptoms and having convergence insufficiency due to muscular imbalance.
- Patients which were healthy human being according to BMI range (18.5-24.9).
- Patients have the age from 10 to 25 years.
- Both genders were included.
- Patients who was willing to participate.

Exclusion criteria:

- Patients with all types of refractive errors.
- Patients with any type of tropia.
- Patients which were unhealthy according to BMI range (18.5-24.9).
- Patients who was taking supplements especially vitamin C.
- All systematic diseases e.g. systemic sclerosis.
- Pregnant or lactating mothers.
- Patients who have computer vision syndrome.
- Patients who have dry eye.

These instruments will be used in this research study

- Optic Ophthalmic Equipment Royal air force ruler (RAF)
- Log MAR chart(Brien Holden)
- Schirmer Tear Test Strips(Surgitech Innovation)

Data collection method:

This Quasi Experimental study was conducted at THQ hospital Karor lal Eason district Layyah. Informed consent were taken from the participants included in the study prior to investigation. Complete history including ocular, medical, occupational and family history was noted. Data were

collected through a self-structured Performa and questionnaire and included demographic information and clinical findings. Patient's chief complaint is asthenopic symptoms like headache, redness, burning and itchy eyes, especially headache when he does near work were selected for further examination. Patients BMI index is also calculated by the patient's height and weight, only those patients were selected who have the normal BMI range which is in between of 18.5 to 24.9. as well as according to inclusion and exclusion criteria subjects underwent different ocular examination which include eye lids, eye lashes, eyelid margins, conjunctiva, sclera, corneal clarity, corneal reflection, pupil size, pupil shape, and pupillary reactions were examined and patients were selected accordingly to meet inclusion and exclusion criteria of research. Then check the visual acuity of that patient was checked by using trial frame, occluder and Log MAR chart. Status of vision of both eyes was taken separately to rule out the cause of asthenopic symptoms. To detect any latent hypermetropia cyclopegic refraction was performed in the subjects presented with asthenopic symptoms. If participant is emmetropic was confirmed then further examination were made full filling the inclusion and exclusion criteria. To detect the anterior segment and posterior segment of eye slit lamp was performed to check the normal crystalline lens of eye and to detect any abnormality in lens i-e pre mature sclerosis in both eyes included in exclusion criteria. After that check the Body Mass Index (BMI) of the participants by using their height and weight. The patients who have the BMI range in between 18.5 to 24.9 were included in this research.

After selecting the patients that were full filling the inclusion criteria of research study. RAF ruler measurements were taken 6cm to 10cm reading were considered as normal. Above 10cm to onward be considered to be abnormal. Participants having more than 10cm at near is considered as patients with convergence insufficiency with asthenopic symptoms during near work were selected for the therapies with their baseline data on first visit to hospital. Then the patients were divided into three groups. And prescribe orthoptic exercise and dietary supplements as the treatment regimen. Orthoptic exercise Brock String test will recommend to one group of patients and describes the process to patients and asked them to do it four times a day. Dietary supplement (Vitamin C) was prescribe to 2nd group of patients and asked them to take it one time a day. And orthoptic exercise with dietary supplements was prescribed to the 3rd group of patients and explains the timing and procedure of treatment. First follow up was done on the 2nd week of after taking the therapy and 2nd follow up was done on the 4th week of after taking the therapy. On every follow up RAF

measurements were taken using RAF ruler and symptoms were assessed through questionnaire used in study. And check the patient's condition whether it's improved or not.

Data analysis method:

After collecting the data using the methodology mentioned above, the data was entered into IBM SPSS (statistical package for social sciences) Version 23 for the analysis of data. The One Way ANOVA test was used to check the effect of given therapies in groups.

RESULTS

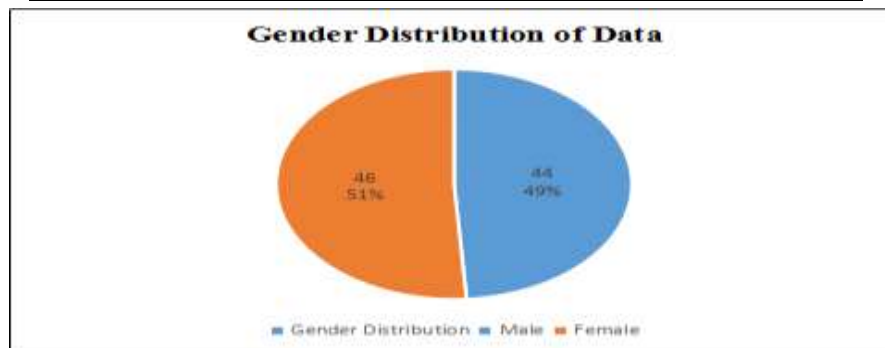
This study, assessed the effect of orthoptic exercise and dietary supplements for the relief of asthenopic symptoms in patients with convergence insufficiency. This study was performed on 90 patients (n=90) with ages ranging from 10 to 25 years. The patients were divided into 3 groups. Each group have 30 patients. Orthoptic exercise (Brock String Test) was prescribed to 30 patients of Group 1. Dietary supplements (Vitamin C) was prescribed to 30 patients of Group 2. Combination of orthoptic exercise with dietary supplement were prescribed to 30 patients of Group 3.

Gender distribution

The study enrolled 180 eyes of 90 patients with convergence insufficiency with complain of asthenopic symptoms during study period. 44 (48.9%) male and 46(51.1%) females were included in this study.

Frequency Distribution of Gender

Gender	Frequency	Percentage
Male	44	48.9
Female	46	51.1
Total	90	100.0



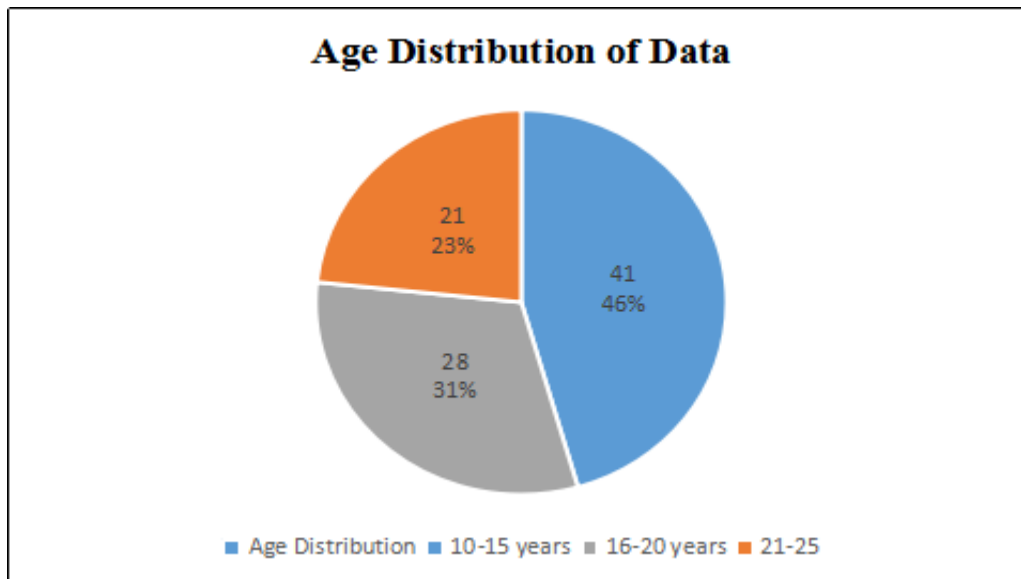
Pie Chart of Gender Distribution

Age Distribution

The patients who receive treatment during study period were divided into three groups according to their age. 41(45.6%) patients were the age of 10-15 years. The second group had 28(31.1%) patients who were 16- 20years of age and remaining 21(23.3%) were the age range of 26-35 years.

Frequency distribution of Age

Age	Frequency	Percentage
10-15	41	45.6
16-20	28	31.1
21-25	21	23.3
Total	90	100.0



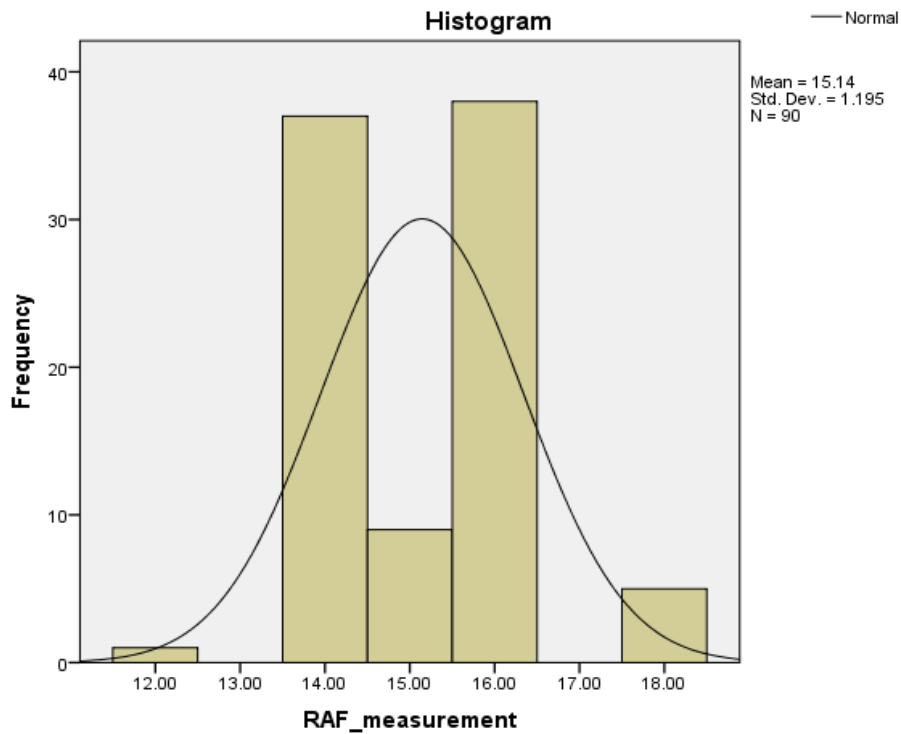
Pie Chart of Age Distribution

Normal Distribution of Data

The normality of data was assessed in 90 patients of convergence insufficiency with asthenopic symptoms, with the saphiro_wilk test. $P > 0.05$ showed that data were normally distributed. Hence, Parametric Pearson correlation was applied. Data was analyzed by SPSS version 23. One Way ANOVA was used for further analysis of data.

Normality Test of Data

	Shaphiro_wilk		
	statistic	df	Sig.
Baseline measurements of RAF	.924	90	0.07



Bar Chart of Normality

Assessment of RAF Measurements on Baseline Data

The One Way analysis of variance (ANOVA) compares the means between the three groups. The patients divided in three groups and each group have 30 patients, and giving them three different therapies. The Group 1 (exercise) have the mean value of RAF measurements was 14.7 ± 0.9 , Group

2 (dietary supplement) have the mean value of RAF measurements was 14.9 ± 0.9 and Group 3 have the mean value of RAF measurements was 15.7 ± 1.4 . Comparison of the all groups showed that there was not significant results $p=1.00(p>0.05)$ is present in the group who was taking dietary supplements only, and significant results $p=0.03(p<0.05)$ was present in the group of who was taking exercise with dietary supplements.

Mean of RAF Measurements on Baseline Data

Therapies	N	Mean	Std. deviation	Std. error	Lower bound	Upper bound	Min.	Max.
Exercise	30	14.733	.94443	.17243	14.380	15.080	14.00	16.00
Dietary supplements	30	14.966	.96431	.17606	14.606	15.326	14.00	16.00
Exercise+ Dietary supplements	30	15.733	1.41259	.25790	15.205	16.260	12.00	18.00
Total	90	15.144	1.19513	.12598	14.894	15.394	12.00	18.00

Significance Value of RAF Measurements on Baseline Data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.422	2	8.211	6.453	.002
Within Groups	110.700	87	1.272		
Total	127.122	89			

Multiple Comparison of Therapies on Baseline Data

Dependent variable	Type of therapy(I)	Type of therapy(J)	Mean Difference (I-J)	Std. Error	Sig.
RAF measurements	Exercise	Dietary supplement	-.23333	.29125	1.000
		Exercise+Dietary supplement	-1.00000*	.29125	.003
	Dietary supplement	Exercise	.23333	.29125	1.000
		Exercise+Dietary supplement	-.76667*	.29125	.030
	Exercise+dietary supplement	Exercise	1.00000*	.29125	.003
		Dietary Supplement	.76667*	.29125	.030

Assessment of RAF Measurements on 1st Follow-up

The Group 1 (exercise) have the mean value of RAF measurements on 1st follow-up was 12.4 ± 0.4 , Group 2 (dietary supplement) have the mean value of RAF measurements on 1st follow-up was 14.0 ± 0.9 and Group 3 have the mean value of RAF measurements on 1st follow-up was 11.2 ± 0.8 . As compared to the baseline measurements to the 1st follow-up, the significance value of RAF measurements was $p=0.00(p<0.05)$.

Mean of RAF Measurements on 1st Follow-up

Therapies	N	Mean	Std. deviation	Std. error	Lower bound	Upper bound	Min.	Max.
Exercise	30	12.4000	.49827	.09097	12.2139	12.5861	12.00	13.00
Dietary supplement	30	14.0000	.90972	.16609	13.6603	14.3397	13.00	15.00
Exercise+ Dietary supplement	30	11.2333	.81720	.14920	10.9282	11.5385	9.00	13.00
Total	90	12.5444	1.36704	.14410	12.2581	12.8308	9.00	15.00

Significance Value of RAF Measurements on 1st Follow-up

	Sum of squares	df	Mean square	F	Sig.
Between Groups	115.756	2	57.878	99.579	.000
Within Groups	50.567	87	.581		
Total	166.322	89			

Multiple Comparison of Therapies on 1st Follow-up

Dependent variable	Type of therapy(I)	Type of therapy(J)	Mean difference (I-J)	Std. error	Sig.
RAF-F1	Exercise	Dietary supplement	-1.60000*	.19685	.000
		exercise+dietary supplement	1.16667*	.19685	.000
	Dietary supplement	Exercise	1.60000*	.19685	.000
		Exercise+Dietary supplement	2.76667*	.19685	.000
	Exercise+Dietary supplement	Exercise	-1.16667*	.19685	.000
		Dietary supplement	-2.76667*	.19685	.000

Assessment of RAF Measurements on 2ND Follow-up

The Group 1 (exercise) have the mean value of RAF measurements on 2nd Follow-up was 10.0 ± 0.0 , Group 2 (dietary supplement) have the mean value of RAF measurements on 2nd Follow-up was 12.6 ± 0.6 and Group 3 (combination therapy) have the mean value of RAF measurements on 2nd Follow-up was 6.8 ± 0.7 . As compared to the baseline measurements to the 2nd Follow-up the significance value of RAF measurements was $p=0.00$ ($p < 0.05$)

According to the mean values of baseline and 2nd follow up of RAF measurements, the difference of mean values is present, which showed that exercise and combination of exercise with dietary supplements give the best results in the patients.

Mean of RAF Measurements on 2nd Follow-up

Therapies	N	Mean	Std. deviation	Std. error	Lower bound	Upper bound	Min.	Max.
Exercise	30	10.0000	.00000	.00000	10.0000	10.0000	10.00	10.00
Dietary supplement	30	12.6667	.66089	.12066	12.4199	12.9134	12.00	14.00
Exercise+ Dietary supplement	30	6.8333	.74664	.13632	6.5545	7.1121	6.00	9.00
Total	90	9.8333	2.46435	.25977	9.3172	10.3495	6.00	14.00

Significance Value of RAF Measurements on 2nd Follow-up

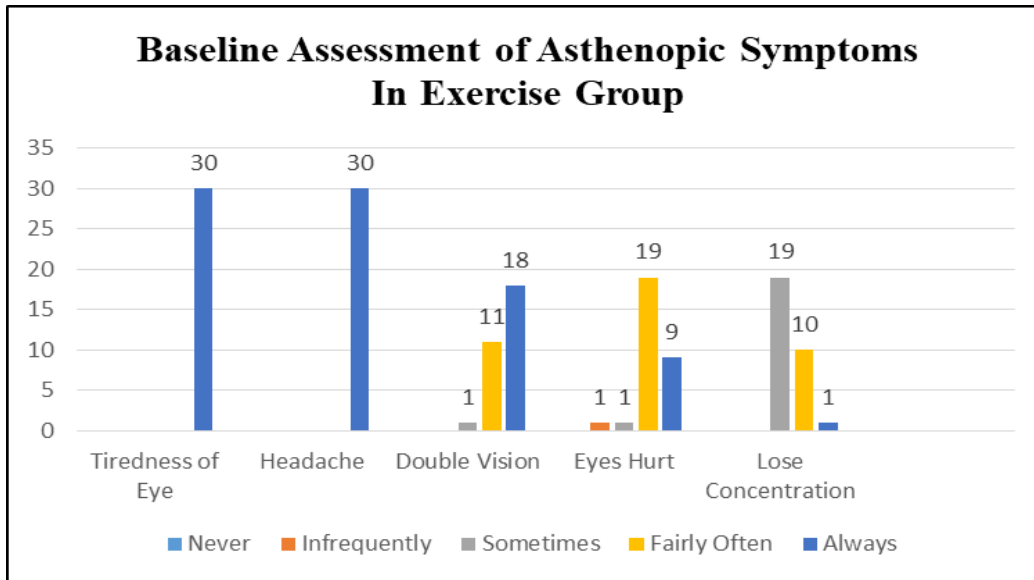
	Sum of squares	df	Mean square	F	Sig.
Between groups	511.667	2	255.833	771.936	.000
Within groups	28.833	87	.331		
Total	540.500	89			

Multiple Comparison of Therapies on 2nd Follow-up

Dependent variable	Type of therapy(I)	Type of therapy(J)	Mean difference (I-J)	Std. error	Sig.
RAF_F2	Exercise	Dietary supplement	-2.66667*	.14864	.000
		Exercise+Dietary supplement	3.16667*	.14864	.000
	Dietary supplement	Exercise	2.66667*	.14864	.000
		Exercise+Dietary supplement	5.83333*	.14864	.000
	Exercise+Dietary supplement	Exercise	-3.16667*	.14864	.000
		Dietary supplement	-5.83333*	.14864	.000

Baseline Assessment of Asthenopic Symptoms in Exercise Group

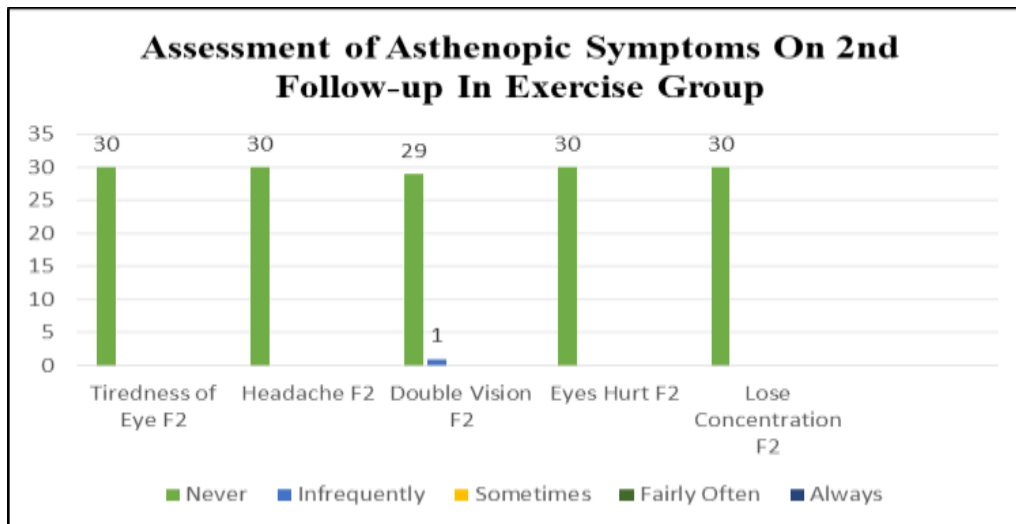
On the baseline measurements of asthenopic symptoms, the highest frequency of patients presented with complain of headache and eye fatigue which is 30(100%) and those patients always experience these symptoms. The patients presented with double vision, eyes hurt and lose concentration was show less frequency. 18(60.0%) patients always experience the double vision, 19(63.3%) patients fairly often experience the eyes hurt and 19(63.3%) patients sometimes experience the lose concentration.



Bar Chart of Asthenopic Symptoms in Exercise Group

Assessment of Asthenopic Symptoms on 2nd Follow-up in Exercise Group

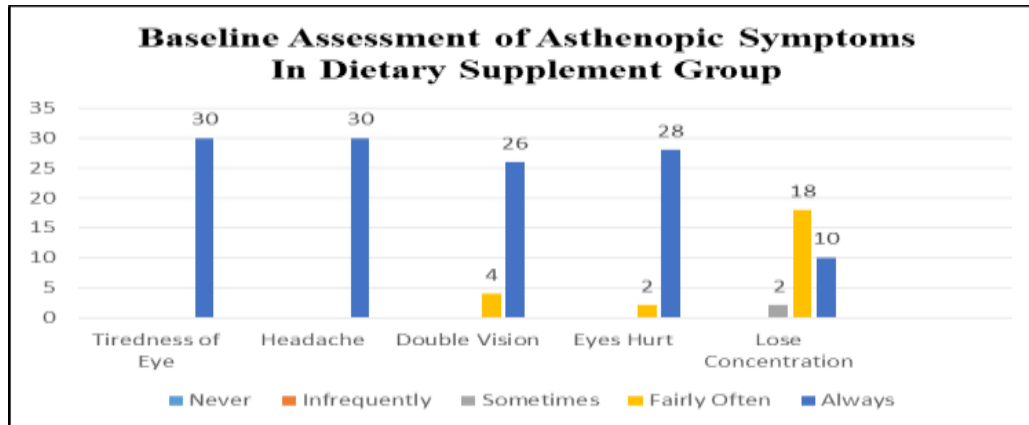
According to assessment of asthenopic symptoms on 2nd follow-up, the frequency of patients was 30(100.0%) which shows that patient came with no asthenopic symptoms on 2nd follow-up in exercise group. Only one patient infrequently experience the double vision which also 99.9% symptom free at their 2nd follow-up.



Bar Chart of 2nd Follow-up in Exercise Group

Baseline Assessment of Asthenopic Symptoms in Dietary Supplement Group

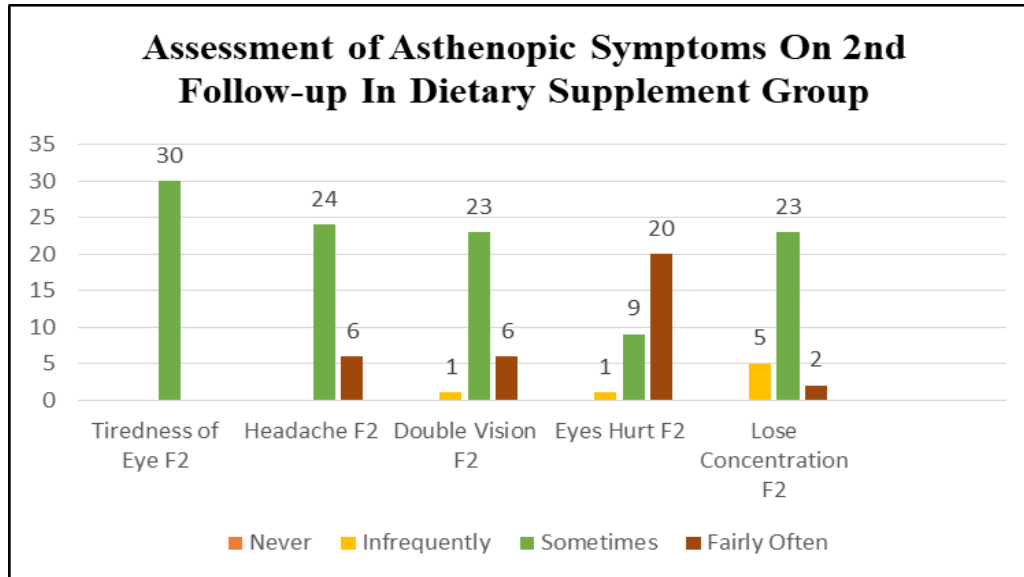
Depending upon the base line assessment of asthenopic symptoms, the frequency of patients presented with tiredness of eye and headache is 30(100%). Those patients always experience these symptoms. 26(86.7%) patients always experience double vision, 28(93.3%) patients always experience eyes hurt and 18(60.0%) patients fairly often and 10 patients always experience the lose concentration.



Bar Chart of Asthenopic symptoms in Dietary Supplement Group

Assessment of Asthenopic Symptoms on 2nd Follow-up in Dietary Supplement Group

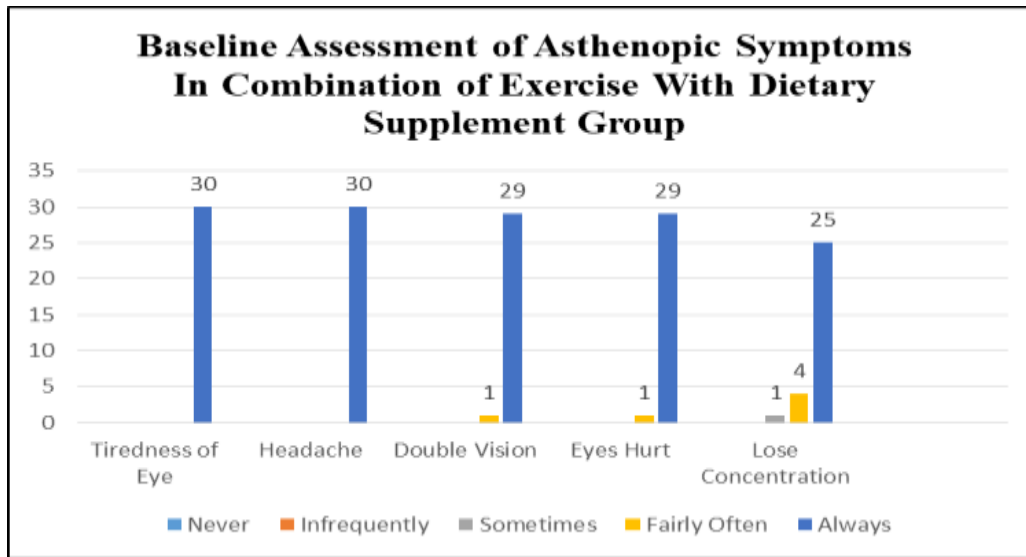
According to assessment of asthenopic symptoms on 2nd follow-up the frequency of patients who experience the tiredness of eye was 30(100.0%). These patients never experience this symptoms again. On 2nd follow-up still 24(80.0%) patients experience the headache, 23(76.7%) patients experience the double vision, 20(66.7%) patients experience the eyes hurt and 23(76.7%) patients experience the lose concentration. This therapy not give the good result towards the relieving of asthenopic symptoms.



Bar Chart of 2nd Follow-up in Dietary Supplement Group

Baseline Assessment of Asthenopic Symptoms in Combination of Exercise with Dietary Supplement Group

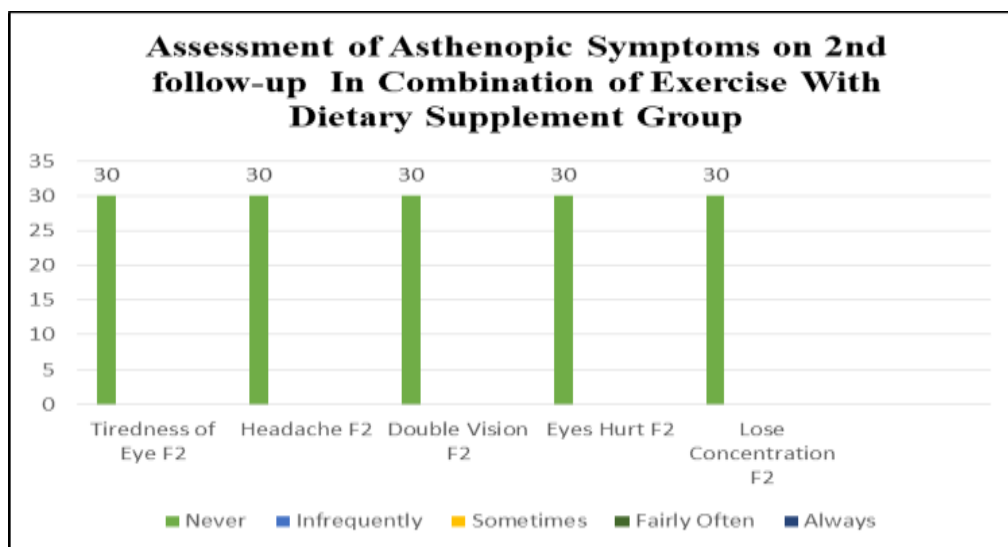
Depending upon the base line assessment of asthenopic symptoms, the frequency of patients presented with tiredness of eye and headache is 30(100%). Those patients always experience these symptoms. 29(96.7%) patients always experience double vision, 29(96.7%) patients always experience eyes hurt and 4(13.3%) patients fairly often and 25(83.3%) patients always experience the lose concentration.



Bar Chart of Asthenopic Symptoms in Combination Group

Assessment of Asthenopic Symptoms on 2nd Follow-up in Combination of Exercise with Dietary Supplement Group

According to assessment of asthenopic symptoms on 2nd follow-up, the frequency of patients was 30(100%). This chart shows that the patients with no asthenopic symptoms on 2nd follow-up was 30 (100%) who was taking combination of exercise with dietary supplement. This is best therapy who give the good results towards the relieving of asthenopic symptoms



Bar Chart of 2nd Follow-up in Combination Group

DISCUSSION

Convergence Insufficiency (CI) is characterized by a decreased ability to converge the eyes and maintain binocular fusion while focusing on a near target. Effect of orthoptic exercises and dietary supplements for the relief of asthenopic symptoms in patients with convergence insufficiency was assessed in current investigation. Total 90 patients were randomly divided into 3 groups. Orthoptic exercise (brock string test), dietary supplement (vitamin C) and combination of both were prescribed to group 1, 2 and group 3 respectively.

A previous study which was conducted in 2015 by Ghadban et al in which they assessed the treatment of convergence insufficiency. The study included the 100 patients in which 50 (50%) were females and 50 (50%) were males. Prisms were prescribed to the patients who were having convergence insufficiency. The initial mean at near was 14.1 prism diopters and at the follow up the mean at near was 11.1 prism diopters which showed that 88% convergence insufficiency was treated by the use of prisms (20). However, in present study the treatment of convergence insufficiency was given to 90 patients in which 44 (48.9%) were males and 46 (51.1%) were females. Brock string test were prescribed to the 30 patients who were having convergence insufficiency. The mean of RAF measurement at the first visit was 14.0 cm, 12.0cm at 1st follow up and 10.0cm at the 2nd follow up. The significance value at the follow ups was $p=0.00$ ($p<0.05$) which showed that convergence insufficiency was treated with the orthoptic exercise. This outcome was correlated with the reference study. Both studies showed that, convergence insufficiency was improved with the therapies. As compared to previous study the current study included the brock string test instead of prisms and results showed that brock string test is more effective for the treatment of convergence insufficiency. There were more females in current study, however the difference was not very large hence no significant gender related changes were observed.

Anupam conducted a study in 2021 to assess the effect of different orthoptics exercises in patients of convergence insufficiency. The orthoptic exercises included in the study were home based pencil push-up therapy and office based orthoptic therapy. The age group of study was 9-30 years. Total 176 patients were included who were having symptomatic convergence insufficiency. Near point of convergence was measured at the first visit and after 6 weeks. Subjects of group 1 was prescribed home based pencil push up exercise and group 2 was prescribed with convergence fusional exercises for the treatment of convergence insufficiency. Participants of both groups had

statistically significant improvement in near point of convergence ($p < 0.001$) (21). On contrary to the previous study, current study included brock string test and combination of brock string and dietary supplements including vitamin C for treatment of convergence insufficiency. Total 90 patients were included which having the age in between 10-25 years. One way ANOVA were applied for the analysis of comparison of therapies. RAF readings were measured at the first visit and after, 2nd and 4th week. Patients of both group had the statistically significant results which were $p = 0.00$ ($p < 0.05$) and also had the improvement in RAF measurements. Previous study and current study correlate in context that, orthoptic exercise gave the relief in symptomatic convergence insufficiency.

Comparison of three vision therapies approaches for convergence insufficiency was performed by Aletaha in 2018. Total 84 subjects were divided into three groups. Group one was given with home based vision orthoptic therapy, group 2 was given office based vision orthoptic therapy and group 3 was given with augmented office based vision orthoptic therapy. The results of this study showed that augmented office-based orthoptic treatment have the significant value was $p = 0.01$ ($p < 0.05$), this significant value showed that augmented office-based orthoptic treatment relatively more effective than the other treatments (22). In present study the patients are also divided into three groups as in previous study but on contrary to that, the current study include different therapies than previous one. The group 1 was given brock string test, group 2 was given dietary supplements including vitamin C and group 3 was given combination of brock string and vitamin C. The combination of brock string and vitamin C therapy have the significance value was $p = 0.00$ ($p < 0.05$) which showed that this therapy comparatively more effective than other two therapies. Current study correlate with the previous study in context that after taking the proper therapy the convergence insufficiency was treated.

Effect of orthoptic exercise upon change in near point of convergence was evaluated by Barbara in 2019. Orthoptic exercise was prescribed to 50 patients. Near point of convergence was measured after follow-up of three and six months. RAF rule was used to measure NPC. The mean value of RAF measurements at baseline, first follow-up and second follow up were 11.16 ± 3.431 , 6.32 ± 2.817 and 5.10 ± 1.961 , respectively. The p value was $p < 0.05$. The results of study showed that patients experienced significant improvement in NPC after the orthoptics exercise (23). In current study the effect of orthoptic exercise upon NPC was assessed in 90 patients after follow up

of 15 and 30 days. Readings were measured through RAF rule. The mean value of RAF measurements at baseline, first follow-up and second follow up were 14.7 ± 0.9 , 12.4 ± 0.4 and 10.0 ± 0.0 , respectively. The p value $p < 0.05$ showed that significant improvement of near point of convergence with orthoptics exercises was observed. The results of this study supported the previous study in the regard of effectiveness of orthoptic exercises upon improvement of convergence in patients of convergence insufficiency.

In 2018 Sheppard undertook a detailed qualitative analysis and assessment of asthenopic symptoms due to digital gadgets. They assessed the effect of dietary supplements and orthoptic exercises upon relief in eye strain and headache. After follow-ups, patients who took only supplements showed a little improvement however the patients with orthoptic exercises as well as dietary supplements showed a significant improvement in relief of eye strain and headache (24). In current study, Vitamin C and combination of orthoptic exercise and vitamin C were given and the results upon asthenopic symptoms including headache, eye strain and double vision, were assessed after 15 and 30 days. The results showed that there was 100% relief of asthenopic symptoms including headache, eye strain and double vision in patients who were using combination of vitamin C and orthoptic exercise as compared to the patients who were using the dietary supplements only gave the 60% relief of asthenopic symptoms including headache, eye strain and double vision. The current study supported the past study in the context that combination of vitamin C and orthoptic exercises is necessary for relief of asthenopic symptoms.

Conclusion

It was concluded that among three groups, group 1 (orthoptic exercise) and group 3 (combination of both exercise and supplement) showed significant results in improving the near point of convergence and relieving the asthenopic symptoms including tiredness of eye, headache, double vision, and eyes hurt.

Limitations

- Poor compliance of patients regarding taking of dietary supplements.
- Poor compliance of patients regarding follow-up visits.
- Lack of awareness about dietary supplements and orthoptic exercises.

Recommendations

- There is the effect of orthoptic exercise upon relief of asthenopic symptoms due to convergence insufficiency, so Eye Care practitioner assess the cause of convergence insufficiency and then prescribed the orthoptic exercise according to the cause.
- Combination of orthoptic exercise and dietary supplements is an effective method to treat the Convergence insufficiency with asthenopic symptoms. So Optometrist must also consider this combination to treat the symptomatic convergence insufficiency.
- When patients came with complain of convergence insufficiency with asthenopic symptoms then Optometrist must refer them to the Nutritionist for proper dietary supplements prescription and intake schedule.
- Awareness campaign/seminar should be conducted to aware the patients that there is the effect of orthoptics exercises and dietary supplements upon relief of asthenopic symptoms due to convergence insufficiency.
- Further studies should be conducted to confirm the sustained benefits of orthoptic exercises and dietary supplements on asthenopic symptoms.

REFERENCES

- (1). Westman M, Liinamaa MJ. Relief of asthenopic symptoms with orthoptic exercises in convergence insufficiency is achieved in both adults and children. *Journal of Optometry*. 2012 Apr 1; 5(2): 62-7.
- (2). Abdi S, Rydberg A. Asthenopia in schoolchildren, orthoptic and ophthalmological findings and treatment. *Documenta ophthalmologica*. 2005 Sep; 111(2): 65-72.
- (3). Evans BJ. *Pickwell's Binocular Vision Anomalies E-Book*. Elsevier Health Sciences; 2021 Jan 7.
- (4). Adler P. Efficacy of treatment for convergence insufficiency using vision therapy. *Ophthalmic and Physiological Optics*. 2002 Nov; 22(6): 565-71.
- (5). Convergence Insufficiency Treatment Trial (CITT) Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. *Arch Ophthalmol* 2008; 126: 1336–49.

- (6). Scheiman M, Mitchell L, Cotter S, Cooper J, Kulp M, Rouse M, Borsting E, London R, Wensveen J. The Convergence Insufficiency Treatment Trial (CITT) Study Group. A randomized clinical trial of treatments for convergence insufficiency in children. *Arch Ophthalmol* 2013; 123: 14–24.
- (7). Rouse M, Borsting E, Mitchell GL, Kulp M, Scheiman M, Amster D, Coulter R, Fecho G, Gallaway M, CITT Study Group. Academic behaviors in children with convergence insufficiency with and without parent-reported ADHD. *Optom Vis Sci* 2009; 86: 1169–77.
- (8). (8). Borsting E, Mitchell GL, Kulp MT, Scheiman M, Amster DM, Cotter S, Coulter RA, Fecho G, Gallaway MF, Granet D, Hertle R. Improvement in academic behaviors after successful treatment of convergence insufficiency. *Optometry and Vision Science*. 2012 Jan 1;89(1):12-8.
- (9). (9). Nunes AF, Monteiro PM, Ferreira FB, Nunes AS. Convergence insufficiency and accommodative insufficiency in children. *BMC ophthalmology*. 2019 Dec; 19(1): 1-8.
- (10). (10). Rouse M, Borsting E, Mitchell GL, Kulp MT, Scheiman M, Amster D, Coulter R, Fecho G, Gallaway M, CITT Study Group. Academic behaviors in children with convergence insufficiency with and without parent-reported ADHD. *Optometry and vision science: official publication of the American Academy of Optometry*. 2009 Oct; 86(10): 1169.
- (11). Borsting E, Mitchell GL, Arnold LE, Scheiman M, Chase C, Kulp M, Cotter S, CITT-RS Group. Behavioral and emotional problems associated with convergence insufficiency in children: an open trial. *Journal of attention disorders*. 2016 Oct; 20(10): 836-44.
- (12). (12). Borsting E, Rouse M, Chu R. Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: a preliminary study. *Optometry-Journal of the American Optometric Association*. 2005 Oct 1; 76(10): 588-92.
- (13). (13). Trieu LH, Lavrich JB. Current concepts in convergence insufficiency. *Current Opinion in Ophthalmology*. 2018 Sep 1; 29(5): 401-6.
- (14). (14). Gallaway M, Scheiman M, Malhotra K. The effectiveness of pencil pushups treatment for convergence insufficiency: A pilot study. *Optometry and Vision Science* 2002; 79(4): 265–7.

- (15). Xu Y, Deng G, Wang W, Xiong S, Xu X. Correlation between handheld digital device use and asthenopia in Chinese college students: a Shanghai study. *Acta ophthalmologica*. 2019 May; 97(3): e442-7.
- (16). (29). Vilela M, Pellanda L, Cesa C, Castagno V. Asthenopia prevalence and risk factors associated with professional computer use-a systematic review. *International Journal of Advance in Medical Science*. 2015 Nov; 3(2): 51-60.
- (17). (30). Vaz F, Henriques S, Silva D, Roque J, Lopes AS, Mota M. Digital Asthenopia: Portuguese Group of Ergophthalmology Survey. *Acta medica portuguesa*. 2019.
- (18). Kawabata F, Tsuji T. Effects of dietary supplementation with a combination of fish oil, bilberry extract, and lutein on subjective symptoms of asthenopia in humans. *Biomedical Research*. 2011; 32(6): 387-93.
- (19). Lem DW, Gierhart DL, Davey PG. Can Nutrition Play a Role in Ameliorating Digital Eye Strain? *Nutrients*. 2022 Sep 27; 14(19): 4005.
- (20). Ghadban R, Martinez JM, Diehl NN, Mohney BG. The incidence and clinical characteristics of adult-onset convergence insufficiency. *Ophthalmology*. 2015 May 1; 122(5): 1056-9.
- (21). (71). Singh A, Saxena V, Yadav S, Agrawal A, Ramawat A, Samanta R, Panyala R, Kumar B. Comparison of home-based pencil push-up therapy and office-based orthoptic therapy in symptomatic patients of convergence insufficiency: a randomized controlled trial. *International Ophthalmology*. 2021 Apr; 41: 1327-36.
- (22). (72). Aletaha M, Daneshvar F, Mosallaei M, Bagheri A, Khalili MR. Comparison of three vision therapy approaches for convergence insufficiency. *Journal of ophthalmic & vision research*. 2018 Jul; 13(3): 307.
- (23). Dawidowsky B, Cerovski B, Klobučar A, Dawidowsky K. Do Orthoptic Exercises Have Any Influence on Children and Adolescents Diagnosed with Convergence Insufficiency and Attention Deficit/Hyperactivity Disorder? *Acta Clinica Croatica*. 2019 Dec 1; 58(4.): 662-71.
- (24). Sheppard AL, Wolffsohn JS. Digital eye strain: prevalence, measurement and amelioration. *BMJ open ophthalmology*. 2018 Apr 1; 3(1): e000146.

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