Check for updates

OPEN ACCESS

DOI: 10.46903/gjms/21.04.1369

ORIGINAL ARTICLE

EFFECT OF GREEN AND RED FILTERS ON HIGH AND LOW AC/A RATIO EMMETROPES

Maryam Muhammad Nadeem[1], Ayesha Mansoor[1], Malaika Younus[1], Rabia Bushra Ehsan[2], Fariah Ata[1] Fareena Tehreem[3]

Departments of Optometry, [1]The University of Faisalabad, Faisalabad, [2]Rashid Latif Medical College, Lahore, [3]Abasyn University, Islamabad Campus, Islamabad, Pakistan

ABSTRACT

Background: Accommodative convergence to accommodation (AC/A) ratio expresses the quantitative relationship between the convergence and accommodation. Purpose of this study was to assess and compare the effect of red and green filters on high and low AC/A ratio in emmetropes.

Materials & Methods: A comparative cross-sectional study was conducted in The University of Faisalabad. Total one hundred (100) emmetropic females from 18 to 25 years of age (20 having low AC/A ratio and 80 with high AC/A ratio) were included in the study through purposive sampling technique after obtaining informed verbal and written consent. Data was collected using self-designed examination based proforma. AC/A ratio was measured with heterophoric method initially without any filters, and then with red and green filters. Data was analyzed using SPSS version 22. Paired t-test was applied to assess the effect of red and green filters on the base line and then independent t-test was applied to compare the effect of red and green filters.

Results: Total 100 emmetropic females revealed that red and green filters have decreased high AC/A ratio and improved low AC/A ratio ($p < 0.001$). Moreover, it was observed that red filters have improved low AC/A ratio (p-0.023) and decreased high AC/A ratio more effectively as compared to the green filters ($p < 0.05$).

Conclusion: This study concluded that the red and green filters improved AC/A ratio and thus, can aid in preventing binocular visual anomalies effectively.

KEY WORDS: Asthenopia; Convergence excess; Eye protective devices; Lens accommodation; Myopia; Phorias.

Cite as: Nadeem MM, Mansoor A, Younus M, Ehsan RB, Ata F, Tehreem F. Effect of green and red filters on high and low AC/A ratio emmetropes. Gomal J Med Sci 2023 Oct-Dec;21(4):255-9. https://doi.org/1046903/gjms/21.04.1369

INTRODUCTION

Accommodation at near, resulting convergence and miosis is a really complex neuromuscular process that occurs to maintain binocular vision at all fixating distances. Near triad results due to synkinesis between accommodation and convergence known as AC/A ratio. This is accommodative convergence generated in response to unit of accommodation. Causes of abnormal AC/A ratio includes general systemic illness, history of trauma or effect of local cycloplegics.[1] The normal range of AC/A ratio is 3-5:1Δ. Disturbance in AC/A ratio can result in refractive errors, non-strabismic binocular visual anomalies as well as strabismus. Myopes exhibits high AC/A ratio while hyperopes had a low AC/A ratio. Moreover, high AC/A can result in convergent squint whereas, low AC/A ratio causes divergent squint (Figure 1).[2]

Corresponding Author:

Dr. Maryam Muhammad Nadeem
Department of Optometry,
The University of Faisalabad
Faisalabad, Pakistan
E-mail: maryammalik057@gmail.com

Date Submitted: 07-02-2023
Date Revised: 11-11-2023
Date Accepted: 23-11-2023

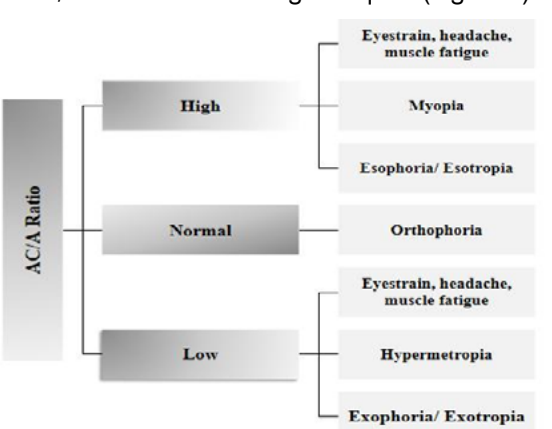

Figure 1: impact of different types of ac/a ratio

In abnormal AC/A ratio, the coordinating mechanism between accommodation and convergence is dis-

turbed and causes fusional imbalance that results in latent deviation.[3] An emmetropic person with normal AC/A ratio, can exhibit 4-6 Δ of phoria at near (esophoria and/ or exophoria), however it can be as high as up to 10 Δ to 12 Δ of exophoria. Horizontal phorias occur due to several anatomical reasons like interpupillary distance and extraocular muscles abnormalities, optical axis variation or can be physiologically due to age. Esophoria occurs more frequently in young age (children) as there is lead of accommodation, especially in hypermetropia.[4]

Patients with the abnormal AC/A ratio can experience asthenopic symptoms, binocular discomfort, headache, eyestrain, double vision (diplopia) and problem in shifting focus from near object to distance object and vice versa leading to several visual problems and even vertigo. Spectacle correction of the refractive error present may not alleviate persisting and associated symptoms. Persistent condition then can leads to manifest deviation.[5] AC/A ratio can be measured using gradient method, heterophoric method and Von Graefe's method.[6,7]

Abnormal AC/A ratio can be treated by providing adequate correction of refractive errors, different vision therapies as well as fusional vergence exercises for binocular anomalies. It includes addressing disturbance of near point of accommodation and convergence. Management can also be done using adequate prisms and colored filters where needed. However, treating any systemic cause or illness if present is essential.

Filters are known for their therapeutic effect on visual performance.[8, 9] Therapeutic use of filters as a syntonic phototherapy is simple as well as non- invasive treatment that uses specific light colors, of definite frequency and wavelength in order to improve brain's regulatory centers. It is really effective in treating chronic headaches, cognitive impairment, stress, learning disorders, Meales's Irlen disease, dyxlexia, improvement of contrast, vision therapies, brain injuries, trauma and concussions, improvement of contrast and visual acuity with photo-therapy.[10] Red filters has greater wavelength about 690 nm and stimulates exclusively cone component (L-cones) of the retina, which in turn excites the fovea. Red light enhances charge of nerve cell that would disrupt synaptic resistance and ultimately stimulates the visual system and improves vision, as biochemistry of the brain is influenced thus sympathetic and parasympathetic nervous system is improved. Red light illuminates major bulk of blood that is flowing in eye and visible light frequencies causes relaxation of arbitrated blood vessel walls. Blood circulation enhances in capillaries to diminish hypoxia and effectively reverses practical symptoms.[11] It is believed that in convergence insufficiency, high exophoria at near as well as decreased stimulus AC/A ratio is seen due to imbalance between the vergence and accommodation adaptive mechanisms.[12] Red filters creates photopic environment, constricts pupil as light of increased wavelength and intensity reaches retina, lens became more globular and accommodation increases due to increased cortical hyper-excitability which in turn sends stimulus to accommodative convergence.[13] Thus, near point of convergence increases, while exophoria decreases this results in improvement of accommodative convergence per accommodation (AC/A) ratio. Red filters are being recommended in albinism, macular dystrophies and in several retinal pathologies, where improvement in the vision is desired. Green filter has optimum wavelength (531nm) as the green cone (M-cone) is placed in the center of the retina, it provides the most optimum and comfortable vision to the eyes. Mesopic condition is created and cortical hyper-excitability decreases (pupil become dilated) and lens become flatten hence amplitude of accommodation is decreased thus, the AC/A ratio is improved. Green filters are prescribed in children and adults with reading difficulties.[14] Objectives of this study were to assess and compare the effect of green and red filters on high and low AC/A ratio among emmetropes in order to include filters as a therapeutic modality in everyday clinical practice besides vision therapies to fix abnormal AC/A ratio to aid in prevention of refractive errors and strabismus.

METERIALS AND METHODS

A comparative cross-sectional study was conducted at optometry lab in The University of Faisalabad from September 2022 to May 2023. Total hundred (100) emmetropic females from 18 to 25 years of age were included in the study after taking ethical approval form the ethical institutional review board (Ref: TUF/IRB/016/021). Inclusion criteria were emmetropia, esophoria and exophoria both at near/distance, patients experiencing asthenopia, high AC/A ratio (≥5.5:1Δ) and low AC/A ratio (≤ 3.5:1Δ). All the refractive errors, tropias, amblyopia, neuromuscular disorder or other ocular as well as systemic pathologies were excluded. Eighty (80) females with high AC/A ratio as well as 20 with low AC/A ratio were included in the study through non-probability purposive sampling technique after obtaining verbal and written informed consent. Data was collected using self-designed examination based proforma. Heterophoric method was used for calculation of AC/A ratio using formula; AC/A= IPD + ((ΔN-ΔD)/D) where IPD stands for interpupillary distance, ΔN for near phoria at 33 cm, ΔD for distance phoria at 6 meters and D for near fixation distance in meters. Interpupillary distance was measured using standard PD ruler.[7] Phorias at near and distance were assessed using Maddox rod and horizontal prism bar while fixating at pen torch as near fixating target and LED bulb as distance fixating target, respectively. Initially AC/A ratio was measured in both groups without using any filters. The same procedure was then repeated and AC/A ratio was measured using red and green filters in each turn separately. Data was analyzed

using SPSS version 22. Using 95% confidence interval firstly, the effect of red and green filters on baseline AC/A ratio was assessed with paired t-test and then effect of red and green filters were compared using independent t-test.

RESULTS

Total hundred (100) emmetropic females from 18 to 25 years of age were included in the study through purposive sampling technique. Twenty (20) of them were with low AC/A ratio while 80 of them had high AC/A ratio, descriptive statistics of age of the participants is shown in Figure 2.

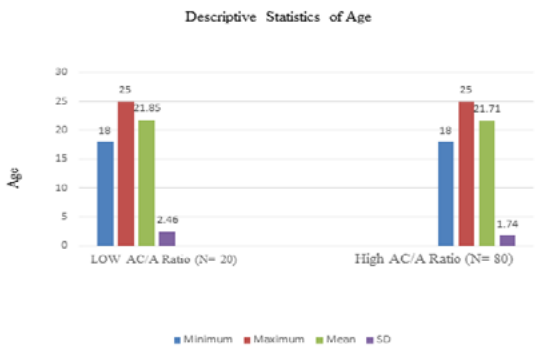

Figure 2: Descriptive Statistics of Age of Low and High AC/A Ratio

Moreover, it was observed that lowest AC/A ratio was recorded in older individuals while highest AC/A ratio was recorded in younger individuals in both the groups as shown in Figure 3 and Figure 4, respectively.

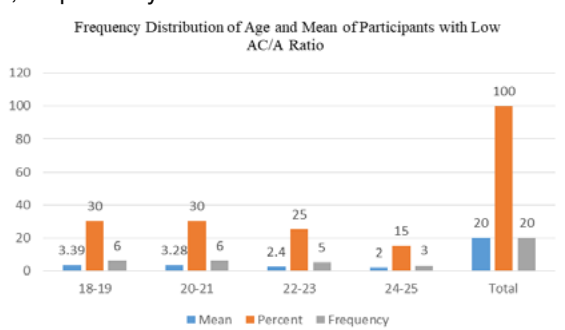

Figure 3: Frequency Distribution of Age and Mean of Low AC/A Ratio

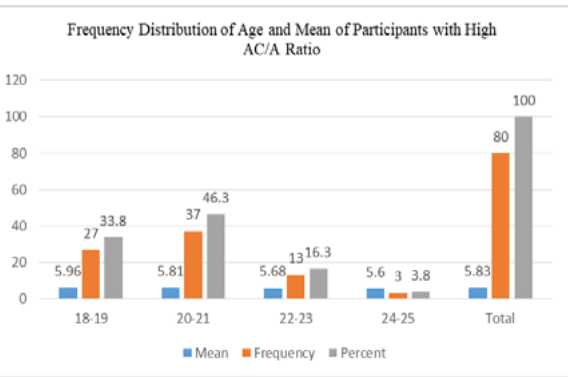

Figure 4: Frequency Distribution of Age and Mean of High AC/A Ratio

The paired t-test showed that there was significant improvement in both low and high AC/A ratio using red filters ($p<0.001$) and green filters ($p<0.001$), respectively (Table 1). Mean low AC/A ratio improved from baseline mean ±SD (2.90:1 Δ ±0.14) to (4.05:1 Δ ±0.79) using red filters and (3.48:1 Δ ±0.72) using green filters (Figure5), whereas, high AC/A ratio mean ±SD (5.83:1 Δ ±0.29) was decreased to (5.41:1 Δ ±0.44) with red filters, and to (5.57:1 Δ ±0.49) with green filters, from the baseline, respectively (Figure 6). Independent t-test was also applied to compare the effect of red and green filters on low and high AC/A ratio. Red filters showed significantly more improvement in optimizing low AC/A ratio ($p=0.023$) and high AC/A ratio ($p<0.05$) as compared to green filters, respectively (Table 1).

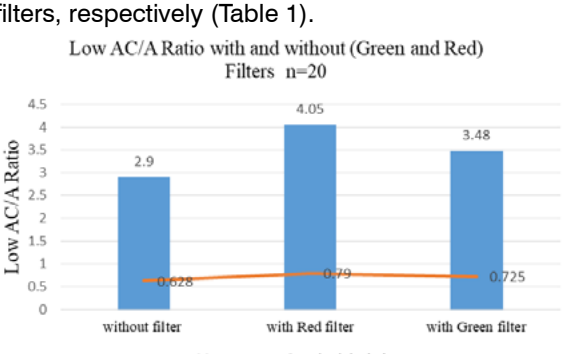

Figure 5: Descriptive Statistics of Participants with Low AC/A Ratio

Table 1: Effect of Green and Red Filters on High and Low AC/A Ratio

Variables	Mean±SD	Sig (2- tailed)
Low AC/A Ratio without Filter - with Green Filter	-0.5785±0.4861	0.000
Low AC/A Ratio without Filter - with Red Filter	-1.1460±0.3607	0.000
Low AC/A Ratio with Red vs Green Filters	0.5675±0.2399	0.023
High AC/A Ratio without Filter - with Green Filter	0.2636±0.3380	0.000
High AC/A Ratio without Filter - with Red Filter	0.4193±0.3380	0.000
High AC/A With Red vs Green Filters	-0.1316±0.0662	0.049

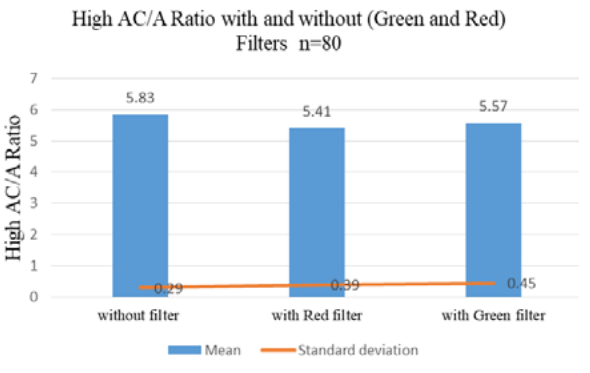

Figure 6: Descriptive Statistics of Participants with High AC/A Ratio

DISCUSSION

In this study effect of red and green filters was assessed and compared on low and high AC/A ratio in order to propose filters as a therapeutic modality to fix abnormal AC/A ratio. Previous management options were treatment of the underlying causes, spectacle corrections, prisms, vision therapies, exercises, conservative management and surgical intervention when adequate. Myopia is the most common and prevalent condition that affect 2.9% of world population[15] with as high as 52% prevalence in Pakistani school going.[16] 25 years and older individuals have (46%) higher tendency to develop myopia. Previous study has suggested, AC/A ratio ≥ 5.84 or more than the subjects were at the risk to develop myopia in coming 1 year by 22.5 times ($p < 0.0001$).[17] Thus, AC/A ratio was concluded as an important risk factor for onset of myopia.[18-21]

This study suggests the use of red filters to prevent myopia, as red filters decreases high AC/A ratio ($p<0.001$). Firstly, phorias were assessed and then by using different formulas AC/A can be achieved. We have used heterophoric method as this includes the Interpupillary distance (IPD) and was easy to apply clinically. The normal range of AC/A ratio vary according to the method being used. For the heterophoric method normal range of AC/A ratio is 3-5:1Δ however it can be upto 6:1Δ according to a few studies[8], therefore we have included high AC/A ratio (≥5.5:1Δ) and low AC/A ratio (≤ 3.5:1Δ). In this study low AC/A ratio improved from mean ±SD (2.90:1 Δ ±0.14) to (4.05:1 Δ ±0.79) using red filters and (3.48:1 Δ ±0.72) using green filters, whereas, high AC/A ratio was decreased from (5.83:1 Δ ±0.29) to (5.41:1 Δ ±0.44) with red filters, and to (5.57:1 Δ ±0.49) with green filters, from the baseline, respectively.

Amaechi and Andosunwoke showed that blue and green filters relax accommodation[14] and Garcia stated near point of convergence was increased using red filters[22], therefore we assessed the effect of green and red filters on the AC/A ratio. This study showed that green filters ($p<0.001$, $p=0.023$) successfully optimsed both the low and high AC/A ratio but red filters were comparatively superior ($p<0.001$, $p<0.05$). However, the limitations of the study were limited age group, the study does not suggests any hours for prescribing therapy, and refractive errors were also not included for a better understanding of the mechanisms of filters but it is recommended that clinicians should assess AC/A ratio of emmetropes, myopes and hyperopes experiencing asthenopia. Red filters must be recommended to patients with high AC/A ratio to prevent myopia as well as in myopic patients to halt myopic progression.

CONCLUSION

It was concluded that the AC/A ratio can be improved with the help of red and green filters. Furthermore, red filters had superior effect in optimizing low and high AC/A ratio as compared to green filters. Moreover, filters have an impact over the reduction in asthenopic symptoms, and thus could aid in the prevention of refractive errors as well as strabismus.

REFERENCES

1. Khurana AK and Khurana B. Theory and practice of optics are refraction. Asthenopia, Anomalies of Accomodation and Convergence; Elsevier.2008;3:103-104.
2. Sagheer S, Haider MA, Bukhari AS, Sattar U, Ahmed I. Comparison of AC/A Ratio in True and Simulated Divergence Excess Exotropia:. Pak J Ophthalmol. 2021; 37(2): 168-172. https://doi.org/10.36351/pjo.v37i2.1192
3. Wajuihian SO. Prevalence of heterophoria and its association with near fusional vergence ranges and refractive errors. African Vis Eye Health. 2018; 77 (1): 1-9. https://doi.org/10.4102/aveh.v77i1.420
4. Cha JW. A comparative study of dissociated heterophoria and associated heterophoria. J Korean Ophthalmic Opt Soc. 2017; 22 (4): 449-57. https://doi.org/10.14479/jkoos.2017.22.4.449
5. Jones-Jordan LA, Mitchell GL, Cotter SA, Kleinstein RN, Manny RE, Mutti DO, et al. CLEERE Study Group. Visual activity before and after the onset of juvenile myopia. Invest Ophthalmol Vis Sci. 2011; 52 (3):1841-50. https://doi.org/10.1167/iovs.09-4997
6. Jackson JH, Arnoldi K. The gradient AC/A ratio: What's really normal?. Am Orthopt J. 2004; 54 (1): 125-32. https://doi.org/10.3368/aoj.54.1.125
7. Azuamah YC, Ukonu SC, Esenwah EC, Ikoro NC, Megwas AU. A Comparative Study of Near Lateral Phoria of Young Adults Using the Von Graefe Technique and Maddox Wing. International Journal of Research and Review. 2022; 9 (5): 367-372. https://doi.org/10.52403/ijrr.20220543
8. Wilkins AJ, Evans BJ. Visual stress, its treatment with spectral filters, and its relationship to visually induced motion sickness. Applied Ergonomics. 2010; 41(4): 509-15. https://doi.org/10.1016/j.

apergo.2009.01.011

9. Lee SJ, Park JH, Lee SH, Whang KH, Ryu GC. The Study on Improvement of Reading Ability for Dyslexia Wearing Color filter lens (ChromaGen TM Lens). J Korean Ophthal Opt Soc. 2011; 16(1): 65-74.
10. Abbas S, Younus M, Bukhari A, Iqrar A, Anwar M. Effectiveness of syntonic phototherapy in amblyopia in terms of improved visual acuity and contrast sensitivity. Pak J Ophthalmol. 2022; 38(3): 205-209. https://doi.org/10.36351/pjo.v38i3.1355
11. Younus M, Abbas S, Nadeem MM, Iqrar A, Naseem K, Bukhari A, Anwar M. Effectiveness of Optometric Photo-Therapy in Amblyopia: Optometric Photo-Therapy in Amblyopia. Pakistan Journal of Health Sciences. 2023; 4(6): 39-43. https://doi.org/10.54393/pjhs.v4i06.857
12. Ostadimoghaddam H, Hashemi H, Nabovati P, Yekta A, Khabazkhoob M. The distribution of near point of convergence and its association with age, gender and refractive error: a population-based study. Clin Exp Optom. 2017; 100(3): 255-9. https://doi.org/10.1111/cxo.12471
13. Amaechi O, Andosunwoke C. Comparative Study of The Effects Of Blue And Green Filters On Binocular Amplitude Of Accommodation. JNOA. 2010; 16: 3-5. https://doi.org/10.4314/jnoa.v16i1.56614
14. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology. 2016; 123(5): 1036-42. https://doi.org/10.1016/j.ophtha.2016.01.006
15. Latif MZ, Khan MA, Afzal S, Gillani SA, Chouhadry MA. Prevalence of refractive errors; an evidence from the public high schools of Lahore, Pakistan. JPMA. 2019; 69(4): 464-467. https://www.researchgate.net/publication/333039001.
16. Saw SM, Chua WH, Hong CY, Wu HM, Chan WY, Chia KS, et al. Near work in early-onset myopia. Invest Ophthalmol Vis Sci 2002;43(2):332-9. https://iovs.arvojournals.org/article.aspx?articleid=2162578
17. Mutti DO, Jones LA, Moeschberger ML, Zadnik K. AC/A ratio, age, and refractive error in children. Invest Ophthalmol Vis Sci. 2000; 41(9): 2469-78. https://iovs.arvojournals.org/article.aspx?articleid=2162387
18. Zhou Y, Zhang D, Ren L, Zhang L. Refractive correction regulated gradient AC/A ratio with low-to-moderate myopia in children and adolescents. Int Ophthalmol. 2021; 41(8): 2705-10. https://doi.org/10.1007/s10792-021-01827-9
19. Price H, Allen PM, Radhakrishnan H, Calver R, Rae S, Theagarayan B, et al. The Cambridge Anti-myopia Study: variables associated with myopia progression. Optom Vis Sci. 2013; 90(11): 1274-83. https://doi.org/10.1097/OPX.0000000000000067
20. Zadnik K, Sinnott LT, Cotter SA, Jones-Jordan LA, Kleinstein RN, Manny RE, et al. Prediction of juvenile-onset myopia. JAMA Ophthalmol. 2015; 133(6): 683-9. https://doi.org/10.1001/jamaophthalmol.2015.0471
21. Gwiazda J, Thorn F, Held R. Accommodation, accommodative convergence, and response AC/A ratios before and at the onset of myopia in children. Optom Vis Sci. 2005; 82(4): 273-8. https://doi.org/10.1097/01.OPX.0000159363.07082.7D
22. Munoz Garcia A. Repeatability of the near point of convergence measurement with the object and the filter methods. Bachelor's thesis: Polytechnic University of Catalonia, UPC. 2017; 26: 1-16. http://hdl.handle.net/2117/182398

CONFLICT OF INTEREST
Authors declare no conflict of interest.
GRANT SUPPORT AND FINANCIAL DISCLOSURE
None declared.

AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	MMN, AM
Acquisition, Analysis or Interpretation of Data:	MMN, AM, MY, RBE, FA, FT
Manuscript Writing & Approval:	MMN, AM, MY, RBE, FA, FT

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.