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Vision Therapy-Based Program for Myopia Control in Adolescents

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Abstract: Vision therapy and rehabilitation have been used to successfully treat a wide range of visual disorders for over 90 years. Eye exercises are considered as one of the vision therapy-based program. Myopia as a refractive defect of the eye could be controlled through the use of vision therapy. The purpose of this study was to investigate the effectiveness of specifically designed eye exercises program on myopia control for Saudi female adolescents. Fifteen female students were recruited from two schools in Riyadh city. They ranged in age from 12 to15 years. A program of eye exercises was practiced by all subjects for six weeks. Visual acuity was measured by the use of an auto refraction device before and after six weeks of training. The results revealed a significant improvement of visual acuity in both right (p=0.028) and left eyes (p= 0.020) indicating that eye exercises as vision therapy-based program could improve visual acuity for female adolescents with myopia.

Key words: Vision therapy % Eye exercises % Visual disorders % Myopia % Visual acuity

INTRODUCTION

Myopia is a refractive defect of the eye in which collimated light produces image focus in front of the retina when accommodation is relaxed. Those with myopia see near objects clearly but far away objects appear blurred. With myopia, the eyeball is too long, or the cornea is too steep, so images are focused in the vitreous inside the eye rather than on the retina at the back of the eye [1].

Myopia is one of the most common visual conditions [2] and internationally, it has been reported in up to 60 to 80% of young adults in Taiwan, Hong Kong and Singapore [3]. Demographically, myopia shows a racial predilection towards Asians; African Americans tend to show the least amount of myopia [4]. Ocular health complications of severe myopia are secondary to elongation of axial length. This can increase the risk for retinal detachments, chorioretinal abnormalities, myopic degeneration and development of glaucoma [5].

Because of the ocular health risks, fiscal impact and high frequency of myopia, there has been great interest for research towards understanding its etiology and slowing its progression. The main goal of myopia control is to retard myopia at a young age-optimally, at its inception-in order to decrease the severity of the condition at maturity [6]. High myopia (greater than -6.00 dioptere [D]) tends to develop in early childhood and may have a more genetic basis. Hyman *et al.* [4] showed that children with myopia of at least -1.25 D by age 7 years were at risk for faster progression of myopia than older children, regardless of other baseline characteristics. Early-onset myopia tends to advance rapidly until early adulthood and presents a higher risk of ocular complications. This can be contrasted with functional myopia, which tends to show a later onset. Functional myopia is related to pseudomyopia or false myopia. It is often associated with nearpoint esophoria, reduced accommodation and accommodative spasm secondary to a long period of nearwork at a short working distance [7].

Saw *et al*. [3] stated that oncerned parents as well as patients themselves may desire to control the advance of myopia in hopes of improving unaided acuity, reducing dependence on glasses, decreasing lens thickness and decreasing axial elongation to lower the risk of ocular disease.

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Eye care practitioners and vision researchers have also shown much interest in techniques that may diminish the magnitude of myopia. Currently, a variety of methods for myopia control have been explored with variable success. This ongoing area of active research has made much progress over the last decade. One of these methods is vision therapy (VT) [8]. Vision therapy is a series of treatment procedures prescribed by optometrists to improve certain types of vision problems that cannot be helped with only glasses or contact lenses [9]. It is much akin to physical therapy for the eyes, during which vision disorders are corrected to improve patients' visual function and performance. It treats vision problems children have when using their eyes up close, especially at school. Problems with tracking, eye teaming and focusing make it impossible for children to read, learn and remain on task. Therefore; VT is a type of physical therapy for the eyes and brain. It is a highly effective non-surgical treatment for many common visual problems such as lazy eye, double vision, nearsightedness and some reading and learning disabilities [10,11]. Visual training programs to improve vision include eye exercises, muscle relaxation techniques, biofeedback, eye patches, or eye massages alone or in combinations [12].

The basis of VT specifically for myopia control is derived from two main models of myopia development with relation to nearwork: the use-abuse theory and the Skeffington nearpoint stress theory. The use-abuse theory states that nearsightedness arises from excessive use of the eyes for nearwork [13,14]. Several studies have confirmed that myopia increases during the school-aged years, but it is yet undetermined if this is due to genetic or other internal growth factors, versus environment, leading to the ongoing "nature versus nurture" debate [4,13,14]. Saw *et al.* [6] found evidence that myopia may have strong environmental influences. In their large scale cross-sectional study, they found an increased prevalence of myopia in urban versus rural areas of Asia correlating with increased nearwork demands seen in urban, school-aged populations. Ciuffreda and Vasudevan [15] found that while nearwork induced transient myopia was associated with momentary accommodative spasm; it also decreased acuity both at near and at distance. Skeffington proposed the other popular theory regarding myopia development. He believed that the increasing cultural emphasis on nearwork tasks is not compatible with our visual and ocular physiology [14]. This incompatibility provokes a stress response to localize vergence closer than the plane of regard. The resulting mismatch causes the symptoms of asthenopia, decreased visual function and avoidance of close work [14,16]. Myopia develops as a form of compensation. In other words, the key element to Skeffington's model is "the drive for convergence to localize closer than accommodation due to the nearpoint visual demands of our culture" [16]. One treatment for this mismatch is low-plus lenses at near to improve the match and visual efficiency. This eliminates the need for adaptation to nearpoint demands [14,16]. Vision therapy addresses both models of myopia development by treating any functional vision problems (associated or causative) and strengthening visual skills. Unfortunately, few large-scale well-controlled studies have been conducted to date validating the effectiveness of VT [17].

There is an increase in optometric treatment by VT, which entails a graded exercise regimen with more frequent visits to the practice for therapy with shorter intervals between office visits. Vision therapy has been shown to be effective in convergence insufficiency [18] and is well established in the USA and some other countries but has not previously been evaluated in Saudi Arabia.

The purpose of this study was to investigate the effectiveness of specifically designed eye exercises on myopia control for Saudi female adolescents aged 12 to15 years.

MATERIALS AND METHODS

Subjects: A total of 15 female adolescents were randomly recruited from two schools in Riyadh city (5 subjects from Al-Khaleej school and 10 subjects from 44-intermediate school for girls). Subjects were included if they: 1) are Saudi female adolescents suffering of myopia not exceeding -3.50 D, 2) aged from 12 to 15 years and 3) wore eyeglasses for at least one year.

Study Design: An exploratory-causal design was applied to investigate the effectiveness of specifically designed eye exercises on myopia control for Saudi female adolescents.

Materials: Auto refraction device (WR-5100k, Autorefractor/ Keratometer) was used to measure the degree of myopia (vision acuity) before as well as after six weeks of eye exercises. A tape measure was used to measure the distance used for some eye exercises. Stop watch was used for time calculation of each eye exercise.

Procedures: Approval from Ministry of Education in Riyadh city was obtained and the consent forms were distributed to the parents after explanation of the procedures in details. A signed consent forms were obtained. The following procedures were applied step by step with each subject: 1) Myopia was measured by an optometrist, 2) An eye exercises program was introduced for all subjects individually and 3) Myopia was measured for each subject after six weeks of treatment by the same optometrist. The eye exercises program included both office and home exercises [19].

Office Exercises: Were Introduced as Follows:

1. Palming exercise; the subject was asked to warm up the hands by rubbing the palms against each other then prepared the palms as follows. The base of the right pinkie will be on the base of the left pinkie making an upside down V with the palms. The subject was then asked to cover up the eyes with the palms. The base of the pinkie fingers will be right on the bridge of the nose (avoid applying pressure to the eyeballs). If the subject is able to see the light through any of the holes between her fingers, she was asked to correct the placement of palms until she got a perfect cover that did not allow any light to get to her eyes. The warmth of the cupped hand combined with blocking out all lights will relax a pair of tense eyeballs. The exercise was performed from sitting position on the school's chair and leaning forwards so that both elbows were rested on the school's desk.
2. Swinging exercise; this exercise works to counteract a frozen gaze and improve eyesight by bringing movement back to the process of seeing. Each subject was asked to focus on a fixed object in front of her while she was in erect sitting position on the school chair. Then she was asked to swing her entire body totally first to the right side then to the left side while she was keeping her eyes on the fixed object. The fixed object was a brightly yellow colored point drawn on the class blackboard that was two meters away from the chair and 1.15 meters height from the ground.
3. Centralization exercise (central fixation); centralization is being fully present and aware in the moment. This exercise trains the eye not to overstrain itself by taking in too much at once. It involves training the eyes to focus on a single point rather than an entire picture. Each subject was asked to look at the parts (part by part) of the colored picture that was placed on the class blackboard that was two meters away from the chair and 1.15 meters height from the ground. She was asked to name each part in the picture. The exercise was performed from erect sitting position on the school chair.

Office exercises 1 and 2 were performed while the subjects were wearing their eye glasses. The office exercises were applied at school time from 8:00 am to 12:00 pm. Each office eye exercise was applied for one minute and three repetitions with 30 seconds rest in-between with a total of nine minutes of training and four minutes rest in-between. Therefore, the office exercises were performed from 13-15 minutes each day for each subject. They were performed on Sunday and Tuesday of each week for six continuous weeks.

Home Exercises: Were Introduced as Follows:

1. Looking into the forehead.
2. Looking into the nose.
3. Looking into the right shoulder without turning the head.
4. Looking into the left shoulder without turning the head.

Each of the home exercises was practiced for half a minute then relaxing for half a minute by closing the eyes and warming them by rubbing the palms and putting them over the closed eyes.

Subjects were asked to practice home exercises twice every day at home, once before studying and the other before sleeping while they were not wearing the eye glasses. Each exercise was performed for one minute and three repetitions with a rest of 30 seconds in-between. Subjects were thus expected to complete 24 minutes of training per day for six continuous weeks.

Statistical Analysis: Statistical analyses were conducted using statistical package for the social sciences (SPSS) version 16 for Windows. Means and standard deviations of the degree of myopia for each eye were calculated. Comparative study was conducted between the mean differences of the degree of myopia before treatment and after six weeks of eye exercises for each eye by the use of the paired samples t-test. The alternative hypothesis was accepted at 5% level of probability ("#0.05).

RESULTS

The statistical analysis was conducted on 15 female students with myopia. Their ages were ranged from 12 to 15 years (mean 13.60±0.99 years). The collected data were statistically analyzed to show means and standard deviations of the visual acuity for each eye before and after six weeks of intervention (Table 1).

Paired samples t-test showed a significant improvement of visual acuity when comparing pre-intervention mean values with that of the post-intervention for the right (p=0.028) as well as for the left eye (p=0.020) (Table 1 and Figure 1).

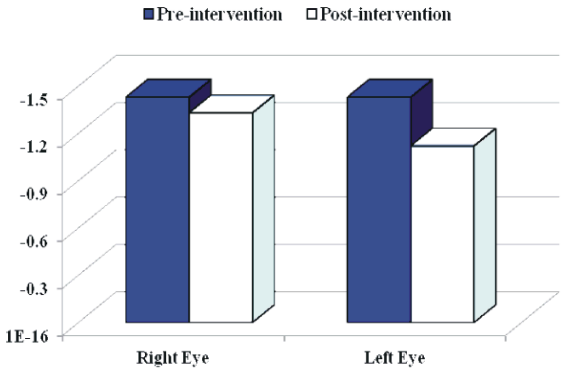

Fig. 1: Visual acuity measures before and after six weeks of intervention.

DISCUSSION

Myopia is a common, complex trait with considerable economic and social impact and, in highly affected individuals, ocular morbidity. The indications are that the prevalence of myopia in young adolescent eyes has increased substantially over recent decades and is now approaching 10-25% and 60-80%, respectively, in industrialized societies of the west and east [20]. It is the optometrist who is primarily responsible for the management of myopia and myopes account for approximately 30% of the optometrist's work.

Myopic persons have many options for improving their vision [21]. Potential therapies range from corrective lenses and surgery to specialty diets, visual exercises and behavioral interventions, all the way to complementary medicine. Alternative treatments present the alluring possibility of changing vision through natural techniques. Such approaches are gaining popularity, as shown by the proliferation of programs for preventing and treating poor vision [22, 23].

In clinical terms it is widely acknowledged that the myopic eye is a vulnerable eye, especially at levels greater than -6D and one that is especially susceptible to a range of ocular pathologies [24-27]. These features have promoted research into the biological, neurophysiological and environmental bases for myopia onset and development and pathways to therapy are being mapped by myopia laboratories throughout the world [21]. Patients are increasingly well aware, often via the internet, of the epidemiology of myopia, its hereditary characteristics and pathological ramifications; therefore the clinical challenge of myopia is both appealing and demanding.

Studies have been applied to investigate the effect of different interventions in slowing the progression of myopia in children and adolescents [3,28,29]. They studied the effectiveness of bifocal spectacles, cycloplegic drops, intraocular pressure-lowering drugs, muscarinic receptor antagonists and contact lenses to control progression of myopia and stated that most therapies for myopia have small treatment benefits that last for a relatively short period of time or have significant side effects. Few studies examined the effect of VT in myopia control [17,30,31].

Eye exercises for natural vision correction are often credited with the work of a man named William H. Bates, who was an ophthalmologist in the early 1900s. The method he invented was called the Bates Method. He theorized that the cause of farsightedness and nearsightedness was tension. Therefore, relaxation techniques could reverse the problems. As the eyes relaxed, they would return to their normal function [32].

Eye exercises have been purported to improve a wide range of conditions including vergence problems, ocular motility disorders, accommodative dysfunction, amblyopia, learning disabilities, dyslexia, asthenopia,

Table 1: Comparison between before and after six weeks of eye exercises for visual acuity.

Measured Eye	Time of Measure	Mean±SD	Minimum	Maximum	t-value	p
Right	Pre-intervention	-1.43±0.66	-2.75	-0.50	-2.45	0.028*
	Post- intervention	-1.33±0.67	-2.50	-0.25		
Left	Pre- intervention	-1.43±0.64	-2.25	-0.25	-3.68	0.020*
	Post- intervention	-1.12±0.69	-2.25	-0.25		

SD: Standard deviation *: Significance

myopia, motion sickness, sports performance, stereopsis, visual field defects, visual acuity and general well-being [33].

The results of this study revealed a significant improvement of visual acuity following an especially designed eye exercises program that was applied for continuous six weeks.

The Baltimore Project (September to December 1943) is the largest study on VT for myopia control. It investigated the effect of VT directly on myopia progression on 103 school-aged and young adult patients with a wide range of myopia (-0.50 D to -9.00 D). Subjects received an average of 25 VT sessions conducted by optometrists and therapists. Overall, the study reported that unaided acuity improved [34,35]. It should be mentioned that there was no standardization of therapy protocol, length or amount of therapy, or determination of refractive error.

Rosen *et al.* [30] studied the effect of visual training on 29 myopic subjects. Subjects received complete optometric evaluations before being randomly assigned to one of three experimental groups. One treatment group received a visual training program with a feedback and reward component, another group received visual training without feedback and reward and the third group was the no-treatment control group. The training lasted for six weeks. The results revealed a significant improvement of visual acuity in the groups who receives visual training.

Rupolo *et al.* [31] investigated the effect of a visual training technique through the use of an acoustic biofeedback technique on visual acuity. They reported that the used visual training technique led to no improvement in objective measures of visual acuity, but did lead to an improvement in one relatively subjective measure of visual acuity and a parallel improvement in psychological conditions. Gallaway and Schieman [36] stated that VT was successful in enhancing negative fusional vergence and eliminating symptoms in the vast majority of patients with convergence excess and should be considered an effective treatment for this condition. Adler [37] investigated the VT in a form of graded routine eye exercises for treatment of convergence insufficiency and stated that although treatment time was slightly long, VT is an effective method for treatment of convergence insufficiency.

Barrett [17] stated that most published studies attempting to evaluate the results of VT are largely based on clinical impressions rather than solid evidence and do not stand to scrutiny. The author stated that traditional in-office VT could improve myopia with a recommended sessions from 12-24 sessions. Lee [38] stated that VT in the form of in-office program and home maintenance therapy is indicated primarily for school-aged or adult-onset myopes and recommended from 12 to 24 in-office sessions for the therapy to be effective. Scheiman *et al.* [39] reported that VT could be used for controlling some visual abnormalities. They stated that VT is effective in improving accommodative amplitude and accommodative facility in school-age children with symptomatic accommodative insufficiency and accommodative dysfunction.

The scientific community is gradually embracing the notion that rehabilitation of motor, sensory and cognitive impairments can alter brain reorganization and result in functional recovery [40]. Therefore, the training and rehabilitation of functional visual disorders through repetitive, targeted visual rehabilitative techniques should not be a foreign concept. Based on what is now known about neuroplasticity, it can be inferred that the mechanism for the efficacy of VT and rehabilitation is through strengthening synaptic connections and inducing cortical reorganization to maximize visual efficiency [41]. The principles emphasized in successful VT are the same principles used by other rehabilitation specialties to maximize recovery of function through induction of neuroplasticity. These include: repetition, motivation, loading, multi-sensory integration and feedback [42].

The findings of this study confirm that treatment of adolescent myopia by VT is an extremely effective treatment modality. The relatively simple and inexpensive treatment procedures, short treatment times and reduction of symptoms should reassure practitioners that VT is an effective tool for controlling myopia. Nevertheless, there is still a need for a multicentre prospective study using a placebo control of exercises resembling VT. In addition, non-invasive neuroimaging should be obtained to assess the changes in neural architecture. In time, cortical plasticity research may play a role in further validating a treatment modality that has improved the visual efficiency of countless patients. It should also be noted that, in this study, there was no masking for the pre- and post-treatment assessments. This is a possible source of bias which could affect the data. To the author's knowledge, this study was the first one that investigated the effectiveness of VT on myopia control among Saudi female adolescents.

CONCLUSION

Results of the current study showed that improvement in visual acuity for Saudi female adolescents with myopia, aged 12 to 15 years, is possible through relatively short term use of eye exercises program. These results suggest that clinicians should consider the use of eye exercises as a way of improving visual acuity for adolescents suffering from myopia.

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