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Physical therapy interventions for reduction of ocular deviation after strabismus surgery

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Abstract

Introduction. The study aim was to examine the effect of physiotherapy exercises on correcting the remaining ocular deviation after strabismus surgery.

Methods. A randomized interventional clinical trial was performed in the Faculty of Physical Therapy, Cairo University, among 40 patients with ocular deviation after strabismus surgery. The participants were randomly divided into an experimental group (n = 20) and a control group (n = 20). All subjects received usual medical care, while the experimental group performed different types of physiotherapy exercises for 2 sessions a week for 12 weeks. The near and far angles of ocular deviation were measured before and after the 12 weeks of treatment.

Results. A significant improvement was observed in the experimental group compared with the control group after 12 weeks of training. There was a reduction in the near angle (19.85 ± 4.09 to 15.4 ± 3.87; 22.41%) and far angle (19.65 ± 4.78 to 16.75 ± 3.9; 14.75%) in the experimental group, with no significant change of the near angle (20.5 ± 3.64 to 20.75 ± 3.19; 1.21%) or far angle (19.7 ± 2.97 to 19.95 ± 3.41; 1.26%) in the control group.

Conclusions. The application of different types of physiotherapy exercises can reduce ocular deviation, restore binocular function, and improve the cosmetic appearance in patients with remaining ocular deviation after strabismus surgery.

Key words: strabismus surgery, ocular deviation, binocular function, physiotherapy exercises

Introduction

Strabismus ('squint') is a common childhood disorder [1], in which one eye is deviated in relation to the other eye when fixing on the same object [2]. Strabismus can affect the life quality and cosmetic appearance, resulting in poor self-confidence, social preconception, fewer job opportunities, and functional disability [3]. Early detection and management of strabismus improve binocular function and the associated psychosocial problems. The most common method for correcting strabismus is surgery; conservative, non-surgical procedures such as eyeglasses, eye drops, eye patching, prisms, and orthoptic exercises failed to improve eye alignment. On the other hand, strabismus surgery complications should be diagnosed and treated early to obtain satisfactory post-operative effects [4].

The goals of strabismus surgery are to correct ocular deviation and to restore binocular function [5]. Sometimes these goals may not be achievable by a surgical procedure because strabismus surgery complications may be the reason for ocular misalignment, limited ocular motility, and tissue adhesion, which require additional treatment or need more operations [6]. According to Awadein et al. [7], 20% of the children needed re-operation after strabismus surgery. Pineles et al. [8] mentioned that 62% of patients attained less satisfactory results and 60% needed repeated operation for one time at least. They also concluded that long-standing surgical effects were less satisfying when one considered sensory status outcomes.

Non-surgical approaches combined with strabismus surgery help restore binocular single and clear vision, improve fusional vergence, and provide control of the manifested deviation. Some authors negate the role of orthoptic therapy such as eye exercise, while others found it to be effective in some types of strabismus, and still others maintain that combined therapy (surgery with eye exercise) is a better approach to achieve long-standing stability of results [9, 10]. Singh et al. [11] concluded that there was no change in the basic angle of deviation in most of patients with intermittent exotropia after orthoptic management but improvement in functional and symptomatic problems was detected in 64–85.7% of the patients. Rathod et al. [12] evaluated the effect of eye focusing exercises on myopia, reporting an improvement in near point convergence in the study group, who applied eye exercises. Also, Pandey et al. [13] conducted the same study in children aged 10–15 years and observed an improvement in visual acuity and near point convergence.

Limited studies have examined the effect of physical therapy exercises following strabismus surgery for improving ocular deviation, so the aim of this research was to evaluate physical therapy exercises in such cases as a complement therapy for eye deviation and for complications that are responsible for some restrictions in ocular motility.

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Subjects and methods

Study design and subjects

The randomized interventional clinical trial was conducted in the Faculty of Physical Therapy, Cairo University. A total of 40 patients suffering from remaining ocular deviation after strabismus surgery were assigned to the experimental group and the control group of equal numbers of participants. Complete clinical evaluation was performed before and after 12 weeks of treatment for each subject. The evaluation included detailed history, visual acuity, and cover test for near and far distance.

The patients, of both genders, were aged 5–15 years. The inclusion criteria were as follows: history of strabismus surgery with remaining ocular deviation, normal sensory and motor fusion, equal or nearly equal visual acuity, good health, and ability to cooperate with the therapist and to do the exercises at home [10]. In turn, the exclusion criteria involved such systemic diseases as myasthenia gravis, multiple sclerosis, Graves' disease, diabetes, and attention disorder, as well as learning disability which could affect vergence, accommodation, or ocular motility [13]. In addition, individuals with any organic ocular disease, optic nerve injury, or mental disorders were excluded [14].

Measurement

A torch and a prism were used to perform the cover test for measuring the near and far strabismus angle. The measurement procedure was applied by an ophthalmologist in the Research Institute of Ophthalmology, Cairo, for all participants before the treatment and after 3 months of treatment.

In the cover test, one of the subject's eyes was covered and uncovered repeatedly to observe whether the non-occluded eye moved or not. The patient was considered to have strabismus if there was movement in the uncovered eye. This movement can be measured by using prisms of different powers which are placed in front of the deviated eye until the movement stops [15].

Equipment

The therapeutic tools applied in the experimental group were a computer with selected video games, a pencil for push-up exercises, coloured balls in equal interval distance fixed with a string, a balance board, and red/blue 3D glasses.

Procedure

Control group

The participants within the control group received traditional care and medication after strabismus surgery.

Experimental group

The patients within the experimental group received physiotherapy exercises beside traditional care and medication after strabismus surgery. The physical therapy exercises were applied in the office and at home. Office exercises involved palming exercise, eye exercises, pencil push-ups, Brock string exercise, thumb exercise (near-distance jump), balance board exercise, proprioceptive neuromuscular facilitation (PNF) exercise, and computer therapy. Office exercises were performed for 2 sessions per week for 3 months. Each session lasted for about 1 hour. Exercises were also done at home from the first session, including eye exercises in all directions, pencil push-ups, thumb exercise (near-distance jump), and dominant eye occlusion for 1 hour daily.

Palming exercise. The patient was asked to place the centre of the palms (not fingers) over their closed eyes very lightly for about 20–30 seconds, 2–3 times per session. The goal of this exercise was to warm up and facilitate mobility of the extraocular muscles [13].

Eye exercises. These have been used for strabismus through eye augmentation to move together in certain directions [10]. In this study, the patient was asked to trace the therapist's finger movements in certain directions, which are up to down, right to left, diagonals, small and large circles with clockwise and counter-clockwise directions. The exercise was repeated 10 times for each direction.

Another eye movement program. The eye movement program consisted of 3 steps: saccadic movements, pursuit movements, adapting movements. The movements in each step were performed 10 times. For saccadic eye movements, the therapist held one pencil in each hand at a distance 1 m away from the patient's eyes. The participant was instructed to look at the pencils in the 2 hands sequentially. For pursuit eye movements, the patient traced the movement of a pencil held 1 m from their eyes by eye movement alone. In the third step, i.e., adapting movements, the therapist fixated the pencil 1 m from the subject's eyes. The patient repeatedly turned their head from right to left and from left to right while fixating their eye on the pencil. After that, other adapting movements were used; the patient repeatedly turned their head from right to left and from left to right with keeping the gaze on the pencil during the opposite movement of the pencil to the direction of the head movement [16].

Pencil push-up exercise. The patient held a pencil at their arm's length, keeping it between the 2 eyes to look at the sharp tip of the pencil. They were asked to move the pencil slowly toward their nose and to return it to the starting point [17]. This exercise aims to improve the individual's ability to maintain easy convergence and binocular function, especially for near objects [10].

Brock string exercise. The exercise is designed to improve eye coordination, to motivate the 'lazy' eye, and to encourage both eyes to work together by using a piece of string (5–12 inches long) and thread with 3 different coloured beads at equal distances from one another. One end of the string was fixed to a rail or was pinned to the wall and the other end was held at the patient's nose. Then, the patient was asked to look at each bead in turn, with a focus on each one [18].

Thumb exercise (near-distance jump). The patient chooses to look at a far object, keeping their arm extended, with the thumb at the height of the observed object. When they focus on their thumb, they should see double images of the farther object. The individual keeps their eye convergence on the thumb, trying to watch the left image of the seen object to notice as many details as possible, and then to watch the right image to notice as many details as possible. Then, reversing the procedure by focusing the sight on the farther object, the patient should see double thumbs to watch the left and right image of the thumb, noticing the image details. This procedure was used in this study to motivate the 'lazy' eye. If one of the images was less clear, more time was needed to work with this eye. The duration of the exercise was 1–2 minutes, and it was repeated 3–8 times per day [14].

Balance board exercise. In this exercise, the patient tried to maintain their balance above a balance board. At the same

time, they followed a movable object with their 2 eyes. During the exercise, pushing the patient in unexpected directions was applied to disturb their balance; the participant was asked to maintain their balance and the tracing of the movable object.

PNF exercise. This exercise acts through stimulating pathways and proprioception receptors [19]. In the present study, PNF exercise was applied through a combination of head and eye movements to reinforce each other. The neck extensor pattern and neck flexor pattern are 2 patterns of PNF combining head movement with eye motion [20].

In the neck extensor pattern, the patient was in a sitting position, and the therapist's hands were on the chin and head of the patient:

– the pattern started with neck flexion, left side bending, and rotation to the right, and ended with extension, right side bending, and rotation to the left;

– the pattern started with neck flexion, right side bending, and rotation to the left, and ended with extension, left side bending, and rotation to the right [20].

The patient was asked to push their head against resistance of the therapist's hand when moving the head toward the ending position. Also, the patient was instructed to move their eyes upward at the same time. The movements were repeated 10 times for each group.

The neck flexor pattern exercise was similar to the neck extensor pattern:

– the pattern started with neck extension, left side bending, and rotation to the right, and ended with flexion, right side bending, and rotation to the left;

– the pattern started with neck extension, right side bending, and rotation to the left, and ended with flexion, left side bending, and rotation to the right [20].

Computer therapy. There are many computer-based eye exercise programs that are used to improve eye muscle movements and encourage better movement of the eye around the eye socket. The patient was asked to stand at a distance of 1–2 feet away from a computer screen [18]. One eye was covered; then, the patient was instructed to follow the movement of a coloured dot around the screen. They were to keep their focus on the dot and avoid disturbance by the background. The same procedure was applied to the other eye and then the exercise was done with the 2 eyes together. Also, the patients participated in a computer therapy game that required red/blue 3D glasses and was designed for the 'lazy' eye. The duration of the computer therapy was about 15 minutes per session.

Statistical analysis

Descriptive statistics and an unpaired *t*-test were applied for comparison of age between the groups. A chi-squared test was carried out to compare sex distribution in the groups. Normal distribution of data was checked by using the Shapiro-Wilk test for all variables. Levene's test for homogeneity of variances was conducted to test the homogeneity between the groups. An unpaired *t*-test served to compare the mean values of near strabismus angle and far strabismus angle between the groups. A paired *t*-test was applied for comparison between pre- and post-treatment status in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analyses were conducted with the Statistical Package for the Social Sciences (SPSS), version 25 for Windows (IBM SPSS, Chicago, IL, USA).

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Cairo University Faculty of Physical Therapy Research Ethics Committee (approval No.: P.T.REC/012/001903). The study was registered with ClinicalTrials.gov (registration No.: NCT04303832).

Informed consent

Informed consent has been obtained from all individuals included in this study and their legal guardians.

Results

Subject characteristics

Table 1 shows the subject characteristics of the study and control groups. There was no significant difference between the groups in the mean age or sex distribution ($p > 0.05$).

Table 1. Comparison of subject characteristics between the groups

Characteristics	Study group	Control group	*p*
Age (years) (mean ± *SD*)	10.75 ± 2.93	10.2 ± 2.58	0.53
Sex, *n* (%)			
Female	9 (45)	9 (45)	1
Male	11 (55)	11 (55)	

Effect of treatment on near strabismus angle and far strabismus angle

Within-group comparison

There was a significant decrease in near strabismus angle and far strabismus angle after the treatment compared with the pre-treatment values in the study group ($p < 0.05$). The decrease in near strabismus angle and far strabismus angle in the study group equalled 22.41% and 14.75%, respectively (Table 2, Figures 1 and 2). Regarding the control group, there was no significant difference in near strabismus angle or far strabismus angle between the pre- and post-treatment status ($p > 0.05$) (Table 2, Figure 1).

Between-group comparison

There was no significant difference in pre-treatment near strabismus angle or far strabismus angle between the groups ($p > 0.05$). A comparison between the groups after the treatment revealed a significant decrease in near strabismus angle and far strabismus angle in the study group compared with the control group ($p < 0.05$) (Table 2, Figure 1).

Discussion

This study showed that physical therapy exercises combined with common medical care after strabismus surgery were more beneficial than common medical care alone in reducing near and far strabismus angle after 12 weeks of intervention. According to the results, the decrease of the angle of deviation was larger for the near angle than for the far angle in the experimental group after the treatment period.

Table 2. Mean pre- and post-treatment near strabismus angle and far strabismus angle in the study and control groups

Angle	Study group	Control group	Mean difference	*t*	*p*
Near strabismus angle (°)					
Pre-treatment (mean ± *SD*)	19.85 ± 4.09	20.5 ± 3.64	–0.65	–0.53	0.59
Post-treatment (mean ± *SD*)	15.4 ± 3.87	20.75 ± 3.19	–5.35	–4.76	0.001*
Mean difference	4.45	–0.25			
Change (%)	22.41	1.21			
t	5.94	–0.52			
p	0.001*	0.6			
Far strabismus angle (°)					
Pre-treatment(mean ± *SD*)	19.65 ± 4.78	19.7 ± 2.97	–0.05	–0.04	0.96
Post-treatment(mean ± *SD*)	16.75 ± 3.9	19.95 ± 3.41	–3.2	–2.76	0.009*
Mean difference	2.9	–0.25			
Change (%)	14.75	1.26			
t	4.39	–0.3			
p	0.001*	0.76			

* significant

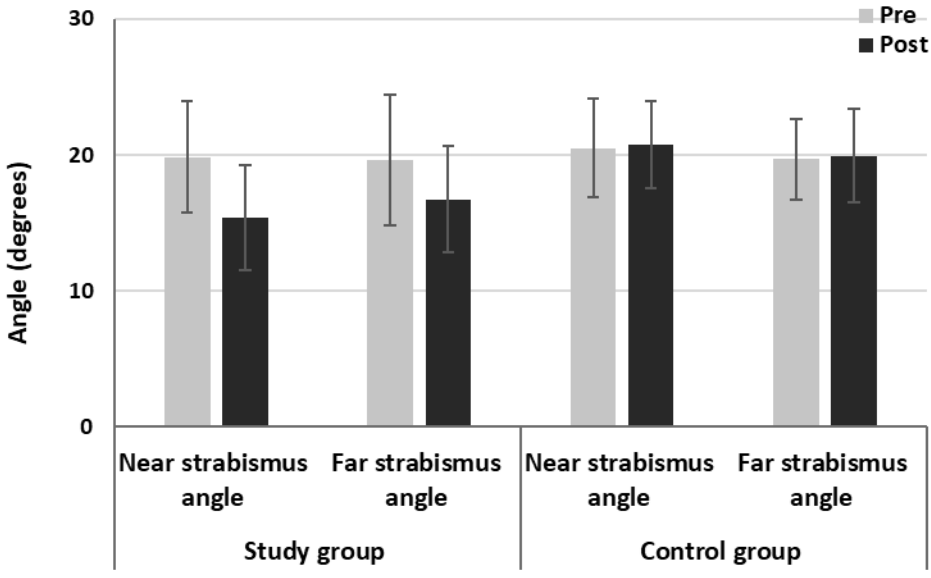

Figure 1. Mean pre- and post-treatment near strabismus angle and far strabismus angle in the study and control groups

Figure 2. Pre-treatment (A) and post-treatment (B) strabismic eyes in the study group

It was interesting to note an improvement in eye control as it changed from poor control to excellent control in all subjects in the experimental group only. In addition, restoration of binocular function was observed in the experimental group. Thus, these exercises not only improved the cosmetic appearance of the eye by providing ocular alignment, but also restored the binocular function and enhanced eye control.

The study results support the results of other research which confirm that eye exercises have positive effects in improving ocular deviation in strabismus patients. Combining eye exercises with surgery is better than surgery followed by traditional care alone. Dhungel and Sharma [9] reported in a single case study that active vision therapy using Brock string exercise and passive vision therapy using spectacles

along with strabismus surgery helped in the management of intermittent exotropia. The limitation of this study was that it described a single case, while multiple case studies should be performed. In the present study, multiple patients were involved, which covers the limitation area of the study by Dhungel and Sharma [9]. Also, numerous types of exercises were used rather than Brock string exercise alone, which could explain the observed improvement. Figueira and Hing [21], in a retrospective review of 150 cases with intermittent exotropia, evaluated the following treatment approaches: (a) surgery with preoperative orthoptic/occlusion therapy; (b) surgery; (c) orthoptic/occlusion therapy; and (d) observation. Surgery preceded by orthoptic/occlusion therapy achieved the highest percent of success (87.5%, 85.7%, 83.33%, and 84.62% at 6 months and 1, 2, and 5 years of follow-up). This approach was better in reducing exodeviation than surgery alone, which presented low success (40%, 42.86%, 36.4%, and 25% at 6 months and 1, 2, and 5 years of follow-up). Exercise improved the surgery outcome if applied before the surgery, as shown in the conclusion of the review by Figueira and Hing [21], or after the surgery, as indicated in the result of this study. Carta et al. [22] evaluated the management of intermittent exotropia in 4 different groups: orthoptic exercises group, surgery group, exercises combined with surgery group, and untreated group. The surgery and orthoptic exercise group attained the best result, which was similar to the one achieved in the present study. Asadi et al. [23] performed a study to evaluate the role of orthoptic treatment in the management of intermittent exotropia. They applied prism exercises and pencil push-ups with the therapist, as well as home exercises involving pencil push-ups with covering of the healthy eye. The result was successful in more than 88% of patients. Our research supports this study in using pencil push-up exercises and eye occlusion for strabismus rehabilitation.

There is no study showing the effect of PNF exercise or balance board exercise on ocular muscles or strabismus before or after surgery. Our study focused on physiotherapy exercises such as orthoptic exercise beside PNF exercise and balance board exercise, which are considered new interventions that can be used for strabismus rehabilitation. Adding PNF and balance board exercises to usual orthoptic exercises, such as pencil push-ups and Brock string exercise, strengthens the outcome in ocular muscles: Park et al. [16] reported that eye movements with PNF training brought about better results than eye movements alone. The rotational multiaxial and multidirectional movements in PNF training were more effective than single-axial movements alone. These exercises were used to enhance the motion, muscle endurance, and muscle harmony through facilitation and control of the neuromuscular system [16, 24]. PNF exercises stimulate the proprioceptors in muscles and tendons, as well as activate or support definite muscle groups [16]. Also, balance stimulation can be incorporated into vision therapy as visual input makes up the sensory information that is used for maintaining balance [25].

Limitations

A limitation of this study is the cooperation of patients, which may have varied among the individuals. Part of this study depended on performing home-based exercises. The more active a patient was in performing the home exercises, the more enhancement of the treatment outcome was achieved, which is considered one of the study limitations. Another limitation was a small sample size, so further studies are recommended. Also, future studies are required to determine the effect of physiotherapy and eye exercise on eye control as this point needs specific research and detailed evaluation.

Conclusions

Physical therapy exercises can improve eye deviation still present after strabismus surgery and increase the eye control. These exercises not only enhance the eye alignment, but also improve the binocular function and cosmetic appearance, which increases self-confidence and social contact.

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Disclosure statement

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Conflict of interest

The authors state no conflict of interest.

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