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THE INFLUENCE OF ACCOMMODATIVE FACILITY TRAINING ON THE NEAR POINT OF CONVERGENCE.

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El Sr. Jaume Pujol i Sra. Clara Mestre, com a director i tutora del treball,

CERTIFICA/CERTIFIQUEN

Que la Sra. Maria Luisa de la Cruz Fiestas ha realitzat sota la seva supervisió el treball *The influence of accommodative facility training on the near point of convergence* que es recull en aquesta memòria per optar al títol de grau en Òptica i Optometria.

I per a què consti, signo/em aquest certificat.

Sr. Jaume Pujol   Sra. Clara Mestre

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Terrassa, 12 de juny de 2017

THE INFLUENCE OF ACCOMMODATIVE FACILITY TRAINING ON THE NEAR POINT OF CONVERGENCE.

RESUM

RESUM

Aquest estudi consisteix en realitzar un entrenament visual basat en la flexibilitat acomodativa per conèixer la seva influència en el punt proper de convergència (PPC) en un grup reduït de pacients. L'estudi va incloure 10 voluntaris sans (7 dones y 3 homes). L'edat mitjana ± SD (desviació estàndard) va ser de 23 ± 2.75 anys. Es van excloure pacients amb estrabisme, problemes binoculars o PPC < 5 cm.

El punt de ruptura del PPC es va mesurar aproximant un estímul, col·locat inicialment a 30 cm, fins que el pacient indicava visió doble. Immediatament després, es va realitzar la flexibilitat acomodativa binocular en visió propera durant 3 minuts. Posteriorment, sense descans, es va mesurar un altre cop el punt de ruptura del PPC.

En l'anàlisi estadístic, la significança es va establir en p < 0.05. En primer lloc, els valors obtinguts per a la variable PPC, van definir un conjunt de dades que es van analitzar amb la prova de Shapiro-Wilk. Mitjançant aquesta prova, obtenim que la distribució de la variable no era simètrica. Per tant, la distribució no era normal. Totes les diferències van ser estadísticament significatives (p<0.05). Els valors de la variable PPC són significativament més grans en la primera mesura que en la segona.

S'ha demostrat que l'entrenament del sistema visual binocular, mitjançant la prova de flexibilitat acomodativa en visió propera, realitzada durant 3 minuts, influeix en el punt pròxim de convergència, de manera que ajuda a apropar el punt de màxima convergència.

RESUMEN

Este estudio consiste en realizar un entrenamiento visual para conocer la influencia del entrenamiento visual, mediante la flexibilidad acomodativa, en el punto próximo de convergencia (PPC) en un grupo pequeño de pacientes. El estudio incluyó 10 sujetos sanos (7 mujeres y 3 hombres). La edad media ± SD (desviación estándar) fue de 23 ±

2.75 años. Se excluyeron pacientes con estrabismo, problemas de binocularidad o PPC< 5cm.

El punto de ruptura del PPC se midió aproximando un estímulo, colocado inicialmente a 30 cm, hasta que el paciente indicaba visión doble. Inmediatamente después, se realizó flexibilidad acomodativa binocular en visión cercana durante 3 minutos. Posteriormente, sin descanso, se midió nuevamente el punto de ruptura del PPC.

En el análisis estadístico, la significancia se estableció en p<0,05. En primer lugar los valores obtenidos para la variable PPC, definieron un conjunto de datos que se analizaron con la prueba de Shapiro-Wilk. Mediante esta prueba, obtenemos que la distribución de los parámetros no era simétrica. Por lo tanto, la distribución no era normal. Todas las diferencias fueron estadísticamente significativas (p<0.05). Los valores de la variable PPC son significativamente mayores en la primera medida que en la segunda.

Se ha demostrado que el entrenamiento del sistema visual binocular, a través de la prueba de la flexibilidad acomodativa en visión próxima, realizada durante 3 minutos, influye en el punto próximo de convergencia, de manera que ayuda a acercar el punto próximo de convergencia.

ABSTRACT

This study consists in performing a visual training to study the influence of accommodative facility training on the near point of convergence (NPC) in a small group of patients. The study included 10 healthy subjects (7 women and 3 men). The mean age ± SD (standard deviation) was 23 ± 2.75 years. Patients with strabismus, binocularity problems or NPC<5 cm were excluded.

The break point of the NPC was measured by approaching a stimulus initially placed at 30 cm until the patient indicates double vision. Afterwards, the binocular accommodative facility was performed in near vision for 3 minutes. Then, without rest, the break point of the NPC was measured again.

Significance was set at p<0.05. First, the values obtained for variable NPC defined a set which was analyzed with the Shapiro-Wilk test. Then, by means of the Shapiro-Wilk test, we obtain that the distribution of the parameters was not symmetrical, therefore, the distribution was not normal. All differences were statistically significant (p<0.05). The values of the NPCsignificantly greater in the first measure than in the second one.

It has been shown that training the binocular vision system through the binocular accommodative facility test performed at near vision for 3 minutes, improves the near point of convergence.

The influence of accommodative facility training on the near point of convergence

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Abstract

Purpose. This study consists of performing a vision training to study the influence of accommodative facility training on the near point of convergence in a small group of patients. The study included 10 healthy subjects (7 women and 3 men). The mean age ± SD (standard deviation) was 23 ± 2.75 years. Patients with strabismus, binocularity problems or NPC<5 cm were excluded.

Methods. The break point of the NPC was measured by approaching a stimulus initially placed at 30 cm until the patient indicates double vision. Afterwards, the binocular accommodative facility was performed in near vision for 3 minutes. Then, without rest, the break point of the NPC was measured again.

Results. Significance was set at $p<0.05$. First, the values obtained for variable NPC defined a set which was analyzed with the *Shapiro-Wilk* test. Then, by means of the Shapiro-wilk test, we obtain that the distribution of the parameters was not symmetrical, therefore, the distribution was not normal. All differences were statistically significant ($p<0.05$). The values of the NPC significantly greater in the first measure than in the second one.

Conclusions. It has been shown that training the binocular vision system through the binocular accommodative facility test performed at near vision for 3 minutes, improves the near point of convergence.

Keywords: Vision Training, Near Point of Convergence, Binocular Vision, Comparability.

Introduction

Binocular vision is the integration of the two retinal images produced by the luminous stimuli that reach each eye in a unique perception of our environment (1). During recent years, the hours dedicated to activities at near vision, like reading or the use of electronic devices, are increasing both at work and in personal life. Consequently, the visual

symptoms related to binocular dysfunctions such as the convergence insufficiency have become more common.

The evaluation of binocular vision consists in determining the existence of alignment of the visual axes that allows binocular vision and if there are dysfunctions in the vergence system that may be symptomatic for the patients. The parameters that are commonly measured in the optometric clinical practice to evaluate the binocular vision are: the phoria or tropia, the near point of convergence, the fusional vergences, the vergence facility and stereopsis.

The most used test to determine the existence of ocular alignment is the cover test (2). This test determines the state of alignment of the visual axes under normal conditions. The examination is performed with the usual correction of the patient and consists of presenting a stimulus of adequate size and that is discernible for both eyes. While the patient is constantly looking at a stimulus located at 40cm, their eyes are alternately covered and the examiner observes the movement. According to the direction of the movement, which is an indicator of a latent or manifest deviation, we used base-in prisms to measure or compensate exophoria or exotropia and base-out prisms to measure or compensate esophoria or esotropia. This test is performed both at far and near distance. The result of this test is compared with the fusion reserves to evaluate if the patient's phoria is compensated.

The near point of convergence (NPC) is the test that evaluates the maximum capacity of convergence maintaining the alignment of the visual axes in the stimulus. This test involves both convergence and accommodation. The break point is determined by approaching the stimulus to the patient until he sees double. Then, the recovery point is determined moving the stimulus away until the patient recovers single vision. If the patient does not indicate double vision, but the examiner sees that the patient loses fixation with an eye, the NPC is determined objectively. The normal values of the break and recovery points are ≤ 10 cm and ≤ 15 cm, respectively.

Fusional vergences evaluate the ability to converge and diverge maintaining the focal plane immobile and the simple vision (3). Positive fusional vergence is tested with base-out prisms and negative fusional vergence with base-in prisms. The prismatic power is increased until the patient reports diplopia. Then, the prismatic power is decreased until single vision is recovered.

The vergence facility test evaluates the ability of the visual system to make fast and precise changes of vergence. It is typically quantified as the number of cycles of convergence and divergence performed in one minute (cpm) placing alternately 3 Δ base-in and 12 Δ base-out. is the normal values are 9 cpm at far vision and 13 cpm at near vision (3).

The most prevalent nonstrabismic binocular dysfunction is convergence insufficiency. Table 1 reports the prevalence of the most common binocular dysfunctions.

Dysfunction	Prevalence (%)
Convergence insufficiency	2.25%-33%
Convergence excess	1.5%-15%
Divergence insufficiency	0.1%-0.7%
Divergence excess	0.8%
Basic exophoria	0.3%-3.1%
Basic esophoria	0.6%-9%
Fusional vergence dysfunction	0.4%-1.5%
Hyperphoria	0.2%

Table 1. Prevalence of the nonstrabismic binocular anomalies in pediatric and adult populations (10).

Convergence insufficiency is a condition in which there is an exophoria at near, orthophoria or low exophoria at distance, a receded near point of convergence, reduced positive fusional vergence, and a low AC/A ratio (3).

The symptoms of this dysfunction generally appears when reading or doing other near vision tasks. They may include eyestrain, headache, blurred vision, double vision, sleepiness, difficulty concentrating on reading, loss of comprehension over time, a pulling sensation around the eyes or movement of the print (10).

This condition may be associated to an accommodative insufficiency and also to an accommodative excess. In this second case, the primary condition to be treated in first place is convergence insufficiency.

Vision therapy is the primary treatment option for convergence insufficiency. The prognosis of this treatment is excellent. Numerous studies have demonstrated the efficacy of vision therapy with success rates between 85% and 95% (1). Vision therapy has been shown to be effective for all ages and might be potentially effective in all cases as long as good motivation and compliance of the patient are present (1).

Convergence excess is a condition in which there is an esophoria at near, orthophoria or low to moderate esophoria at distance, reduced negative fusional vergence at near, reduced negative fusional vergence, and a high AC/A ratio. This condition is one of the most prevalent (10).

Most symptoms are associated with reading and near tasks. Common complaints include asthenopia and headache after short periods of reading, intermittent blur or diplopia, sleepiness when reading, difficulty concentrating, and loss of comprehension over time. The main vision therapy exercises will be focused on the use of base-in prisms and negative lenses.

Divergence insufficiency is a condition in which there is an esophoria of 2Δ to 8Δ at distance and slight esophoria at near, normal versions, and reduced negative fusional vergence at distance (3). It is the least prevalent nonstrabismic binocular dysfunction (10). The most common symptoms are intermittent diplopia at distance, eyestrain, blurred vision or difficulty focusing from far to near (10).

Prism prescription is the primary treatment option for divergence insufficiency, although the use of lenses, added lenses, and vision therapy may also be helpful (3). If the prescription of prism is not successful in eliminating the patient's symptoms, vision therapy is indicated (3).

When visual therapy is used to treat divergence insufficiency, the overall goals are to increase the negative fusional vergence amplitude at distance and to improve fusional facility permitting the patient to make rapid changes in vergence and accommodation with comfort and without diplopia (3).

Divergence excess is characterized by a greater amount of exophoria at distance than at near and high AC/A ratio (3).The symptoms are associated with distance tasks: complain of eye turning out, and closing one eye with bright lights.

Although divergence excess affects mainly at far distance, the initial objectives of visual therapy are to normalize accommodation and fusional vergence skills at near. As these abilities improve, the training distance is gradually increased.

The basic exophoria is defined as an elevated and decompensated exophoria of similar magnitude both at far and near distance. It is also characterized by normal AC/A, insufficient convergence reserves at far and near distance, and NPC may be receded (2). This condition shares symptomatology and signs with both divergence excess and convergence insufficiency.

The basic esophoria is characterized by an endophoria of similar magnitude both at far and near distance, normal AC/A ratio, and diminished reserves of divergence at all distances. The worst prognosis of visual therapy is shown with basic esophoria. In this condition, it is recommended to fully correct hypermetropia and the use of base-out prisms (2).

Fusional vergence dysfunction is an anomaly in which both the positive and negative fusional vergence ranges are reduced and can effect both distances, being more frequent in near vision (3). Most symptoms are related to work at near vision highlighting asthenopia, blurred vision and headache. The first choice treatment in this condition is the vision training to increase the fusional vergences (5).

The vision therapy is a clinical procedure to correct several ocular dysfunctions and develop more adequate pursuit, saccadic, accommodative, and fusional abilities of the patient (11). The visual skills learned during vision therapy should be done automatically

and without conscious effort. From the patient's point of view, the main aim of vision therapy is the elimination or a considerable reduction of the symptoms.

There are several studies that demonstrate the utility and effectiveness of vision therapy in improving visual skills. A study conducted to investigate the pattern of symptoms in children with convergence insufficiency, before and after treatment indicated that the children who responded to treatment typically reported a decrease in symptoms for both performance-related and eye-related symptoms (8).

The objective of this study is to analyze the break point of the NPC before and after performing a continuous exercise of binocular accommodative facility in order to determine if the NPC improves after a training with an exercise which involve both vergence and accommodative abilities.

Methods

Subjects

This study was conducted at the Davalor Research Center. The study included 10 healthy subjects (7 women and 3 men) recruited from the staff and students of the Universitat Politècnica de Catalunya (UPC) (Terrassa, Spain). The mean age ± 2.75 SD (standard deviation) was 23 ± 2.75 years (range from 18 to 30 years).

Before performing this study, all patients previously gave their verbal consent. The monocular visual acuity was equal or greater than 20/20 visual acuity in near vision and far vision in both eyes and participants had no history of any ocular. Patients with strabismus, binocularity problems or NPC < 5cm were excluded.

Examination Protocol

Firstly, the break point of the NPC was measured by approaching a stimulus initially placed at 30cm until the patient indicates double vision. Afterwards, the binocular accommodative facility was performed in near vision for 3 minutes. Then, without rest, the break point of the NPC was measured again. This procedure was always performed by the same examiner.

Equipment. The tests were performed in an optometric cabinet, with maximum light of the phoropter, a 20/25 visual acuity test for near vision at 40 cm, flippers with +/-2 D lenses, and a pen to stimulate the convergence during the NPC measure.

Statistical analysis

The statistical analysis was performed using the software SPSS Statistics versions 22 (IBM Corp.,USA) for Windows and the Microsoft Office Excel 2007 (Microsoft Corp., USA). In all cases a 95% confidence interval was considered.

Significance was set at *p*<0.05. First, the values obtained for variable NPC defined a set which was analyzed with the *Shapiro-Wilk* test. This test was used to know if the distribution of the parameters was symmetrical.

The Wilcoxon signed-rank test was performed to determine whether the NPC improved significantly after the training. The standard deviation intrasubject of the parameters was calculated. Finally, to study the agreement between data, the data were represented in *Bland and Altman* plots.

Results

The descriptive data (median and interquartile range) for two variables computed are shown in Table 2. As expected, the value NPC 2 is smaller than the value NPC 1. The value NPC decrease after the binocular accommodative facility.

Parameter	Median	IQR=Q3-Q1
NPC 1	10,05	3,125
NPC 2	8,70	3,125

Table 2. Descriptive statistics table. Median and SD of the variables NPC1 and NPC2.

Then, by means of the Shapiro-wilk test, we obtain that all data the distribution of the parameters is not symmetrical, therefore, the distribution is not normal. The within subject standard deviation is SDws=1,19.

Consequently, a Wilcoxon test was used to determine whether there were statistically significant differences between the values of both measures of the NPC. The P-valor was 0.007, therefore the differences between the two measures was statistically significant.

Parameter	NPC 2 – NPC 1
Z	-2,692
Sig.	0,007

Table 3. Wilcoxon Signed-rank test. P-valor and Z for the variable NPC.

The Bland and Altman plot show the mean of the differences and corresponding 95% limits of agreement between the values provided by the NPC 1 (first measurement of NPC) and NPC 2 (second measurement) (Figure. 1). The scatter of points in the graph is high, the parameter values differ significantly. Although only two points are outside the limits of

agreement, the amplitude of the limits is wide and therefore most points are within the limits.
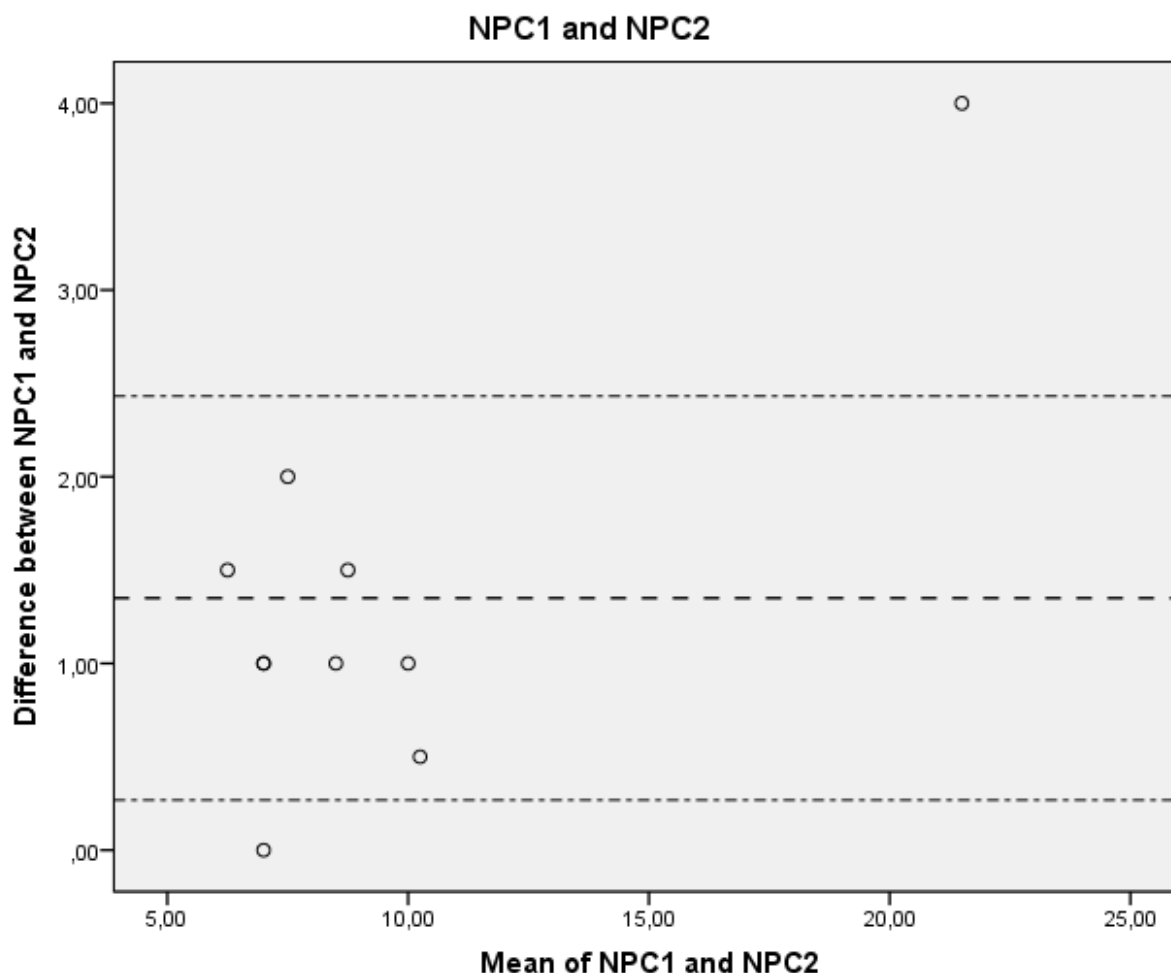
Figure 1. *Bland and Altman plots.*

Discussion

In the present study, it was investigated the agreement of several measurements of the NPC variable provided by the tests performed at the Davalor Salud clinic. Firstly, it can be deduced from our results that not good agreement between measurements from both sessions exists. The results of the study are consistent with the results of other studies mentioned above that demonstrate the effectiveness of vision therapy in binocular vision dysfunctions. (8)

According to the statistical analysis of our study, vision training has an effect on the measurement of the near point of convergence. According to the results obtained, the first NPC measurement give a higher value than the second NPC measure assessed after the binocular accommodative facility training. In addition, the p-value < 0,05 indicates that the

discrepancy between the two sessions is high. Therefore, there is a considerable change in the NPC2 measurement performed after vision training. In this case, we expect the p-value to be less than 0,05 since this discrepancy between the values of the two sessions would indicate that vision training causes a significant effect on the test.

Surprisingly, only one outcome of the study has not met expectations, specifically one patient in the study reported no change in the NPC value after performing vision training. This could be because the NPC value was already good enough or small (7cm). The rest of patients did show improvement after training. In addition, they had and NPC1 ≥ 7cm value.

It is possible that the data obtained were not normal according to the statistical analysis, because the sample studied was small.

Conclusion

It has been shown that training the binocular vision system through the test of the binocular accommodative facility, performed in near vision for 3 minutes, influences the near point of convergence in a way that helps to bring closer the near point of convergence.

We can conclude that if this short training has shown that accommodative vision training influences the results of the NPC, if a well-planned vision therapy is performed, it could also produce improvement as shown by other studies that deal with vision therapy.

Acknowledgments

Ethical and social commitment

According to the regulation, the Final Project must contain a section which refers to the social and ethical commitment. Therefore, this section analyzes the work from an ethical point of view and also refers to the social and legal implications involved in the study.

It should be noted that the main objective of this work is to do a study to determine the influence of the vision training using an existing technique on the near point of convergence. Both research and knowledge in the field of health sciences has direct impact on improving the eye health of the population and therefore in their quality of life.

Regarding the legal aspects, two fundamental aspects should be treated. First, it was not considered necessary that the people who have voluntarily participated in the study sign an informed consent, because all of them were staff and/or students form the Universitat Politècnica de Catalunya. On the other hand, all the measurements were completely safety for the patients. In no case dangerous instruments has been used and the measurements could not damage their eye health.

References

1. Pons Moreno Á.M. Fundamentos de la visión binocular. Universitat de València, editor. 2004.

2. Borràs, M.R; Gispets, J.; Ondategui, J.C.; Pacheco, M.; Sánchez, E.; Varón, C. Visión binocular. Diagnóstico y tratamiento. 1ª ed. Edicions UPC. 1996.

3. Scheiman M; Wick B. Clinical Management of Binocular Vision. Heterophoric, Accommodative, and Eye Movement Disorders. 4th ed. Sm. 1994.

4. Rosner, J.; Rosner, J. Vision therapy in a primary-care practice. New York, Professional Press Books, 1998, 20-27.

5. Martín R VG. Manual de optometría. Madrid: Ed. 2010. 677 p.

6. Rowe FJ. Clinical Orthopics. 2nd ed. Bl. 2004.

7. Manuscript A. Vision Therapy/Orthoptics for Symptomatic Convergence. NIH Public Access. 2011;87(8):593–603.

8. Scheiman M, Kulp MT. Symptoms in Children with Convergence Insufficiency: Before and After treatment. 2013;89(October 2007):1512–20.

9. Talasan H, Alvarez TL. Disparity vergence responses before versus after repetitive vergence therapy in binocularly normal controls. 2016;16:1–19.

10. P. Cacho, Á. García, M. Ruiz. *Journal of Optometry*. Do we really know the prevalence of accommodative and nonstrabismic binocular dysfunctions. 2010; 185-197.

11. Martin H. Birnbaum, O.D. Optometric Management of Nearpoint Vision Disorders. 2nd Edition. State University of New York. Butterworth-Heinemann, editor. 1994.