How reading speed is affected by prism correction in exophoric patients

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Abstract

Reading is a very crucial part of life. Good reading ability is necessary for daily tasks. People who have difficulty in reading (for any reason) can find it very frustrating throughout the day and can suffer from symptoms such as headaches, eye strain, etc. Reading speed is a factor that can indicate reading ability.

Among many different factors that affect reading speed, one of the factors is the condition of exophoria. This is when the eyes tend to diverge and usually presents with difficulty to converge. When reading at a near distance the eyes must converge, making reading more difficult for people with exophoria.

Measuring the eyes' deviation can be performed in different ways, giving different amounts of prisms needed to correct the exophoria and give more comfort. In this study, two methods are used (Fixation Disparity and Maddox Rod) to determine how many prisms would be necessary to prescribe and then test reading speed with each number of prisms.

The results showed no significant difference in reading speed using each method to test for prisms, although subjectively it appears that there is a trend toward faster reading with prisms measured according to Fixation Disparity.

Keywords: exophoria; reading speed; convergence inssuficiency

1. Introduction

Reading is a fundamental skill that is necessary to successfully navigate daily life and is used to navigate basic needs as well as to obtain higher education (Trauzettel-Klosinski et al., 2012). Reading is a skill many people take for granted, but the act of reading and properly comprehending a text is a complex and interactive process. It requires several different brain functions to work together. Reading well requires one to puzzle through multiple layers of context and meaning (Yurko & Protsenko, 2020). People spend most of their lives reading; particularly since technological advancement has entered the world, most information

today is obtained by reading. Reading in the 21st century includes reading for education, reading for leisure, reading for work, and reading for social interaction, as well as reading to navigate the world. In the past, reading was primarily utilized in order to become more educated and to increase our knowledge. In today's age of digitalization, reading is a necessity, not a luxury.

It has been shown by Ayodele (2013) that ease of reading affects learning outcomes. In order to ensure efficiency, reading must be extremely comfortable. When reading is comfortable it requires less effort. The easier the task of reading is, the faster and more efficient it will be.

Vision is a basic prerequisite for reading. In order to read, visual acuity must be good enough to enable letter recognition. But that is just the first visual skill needed for proper reading. Additionally, when reading, it is necessary for both eyes to focus on the same point in space and move together from word to word, to ensure one single, focused image at all times. Those skills are reached through coordination of lower-level oculomotor processes such as version, accommodation, and vergence. Reading also involves higher-level non- oculomotor processes (e.g., attention, language, cognition, and memory) (Thiagarajan, 2012).

When these abilities are not up to par, reading speed is adversely affected and reading will be less efficient, more difficult, and may cause headaches, exhaustion, and discomfort.

Reading speed can be affected by many different causes, eye-related or others. One of the primary causes of discomfort in reading is vergences. Vergences are the movement of the eyes in towards a near target or out towards a distant target in opposite directions simultaneously in order to maintain or obtain a single binocular image. These vergences can be inwards, referred to as convergence, or outwards, referred to as divergence (Wajuihian, 2017). When these movements are not correspondent, one can suffer different anomalies that can cause difficulty reading or any other close/distance work.

Exophoria is the tendency of the eyes to deviate horizontally outward; the visual axes diverge from the perfect alignment under dissociated conditions, meaning in the absence of fusion (Gantz & Stiebel-Kalish, 2021; Sanker et al., 2012). Exophores have a slower convergence reaction compared to their divergence reaction (Alvarez, 2015). Exophoria at near is the basic diagnostic criteria for the diagnosis of convergence insufficiency (Borsting et al., 2003).

Convergence insufficiency (CI) is a condition in which the exophoria at near is greater than exophoria at distance. CI can cause symptoms at near work such as eye strain, double vision, eye fatigue, frequent loss of place, slow reading, headaches, and short attention span (Scheiman, 2011).

According to Scheiman and Wick (1977), the natural position of the eyes is 1±1 Prism Diopters (PD) exophoria at distance and 3±3 PD exophoria at near (although more recent research by Yekta et al. (2017) found values of 1.15 exophoria±2.04 PD for distance and near dissociated phoria: 5.02 exophoria±4.74 PD, associated phoria: 0.55 base-in±1.02). When the eyes are positioned outward more than the normal amount for near distance and at least four PD more than the distance exophoria, this is considered Convergence Insufficiency. Depending on the Near Positive Fusional Vergence (PFV) values, if there is no ability to overcome this deviation a strabismus will appear and there will be either diplopia or suppression. If PFV values are within normal limits, there will be normal vision but the effort to overcome the exophoria and get normal vision will be extreme, causing symptoms such as headaches, asthenopia, slow reading, etc.

Exophoria can be caused by anomalies such as eye muscle weakness, nervous system issues and cognitive anomalies. Size and shape of the eye can also cause exophoria. In addition, exophoria can also be the result of a refractive error. Refractive error is when the shape of the eye causes the light to focus in the wrong place in the eye, either before or after the retina (National Eye Institute, 2020). Gupta et al. (1987), tested 250 cases of exophoria and found that 59% of the cases had a refractive error, with myopia as the most common refractive error. However, the correlation between the amount of myopia and the amount of exodeviation could not be established. Subjects with exophoria may suffer severe discomfort with near distance work such as eye tension, headaches, and pain in the upper eyelids (MacDonald, 1931).

There is no conclusive data about the prevalence of exophoria. There is a huge range of articles discussing prevalence of convergence insufficiency, some of them using near exophoria as a criterion for convergence insufficiency, but a recent article reviewing the literature of convergence insufficiency and exophoria found large differences among studies due to variations in outcome measures, age, and gender distributions in samples. This may account for the wide variation of reported prevalence, ranging from 1.7% to 33% (Gantz & Stiebel-Kalish, 2021).

Treatments for exophoria are diverse. One option is base-in prism glasses, used to reverse the outward eye movement and reduce asthenopic symptoms. Another treatment is Vision Therapy and eye exercises, teaching the eyes to easily converge even though the easier eye movement would be to diverge (Lavrich, 2010). Additionally, in some cases of extreme difficulty, occlusion or surgery may be warranted.

One paper in the field compared all non-surgical treatments for convergence insufficiency, including base-in (BI) prism glasses, showed no difference between the group wearing BI glasses and the placebo group in terms of symptoms (Scheiman. 2020). A different trial conducted on presbyopes showed that base-in glasses in progressive addition lens design was more effective and decreased symptoms compared to regular progressive correction (Scheiman et al., 2011). Another study by Stavis et al. (2002) wanted to determine whether base-in prism glasses correction can diminish symptoms when reading at near and improve reading abilities. The results showed a significant improvement in reading speed, accuracy, and comprehension in the group with base-in glasses correction. Patients also reported having an improvement in asthenopia and headaches. One trial evaluated the effectiveness of base-in prism reading glasses and found no evidence of a difference between the prisms reading glasses and the placebo reading glasses when measuring the outcome of near point of convergence (NPC), positive fusional vergence or symptom scores measured by the Convergence Insufficiency Symptom Survey (CISS) (Scheiman et al., 2020).

As for convergence exercises, evidence from two trials showed that in-office treatment of vision therapy was more effective than home-based exercises in children. (Scheiman, 2011)

A review by Scheiman et al. (2020) reviewed 12 trials evaluating non-surgical approaches to treating convergence insufficiency: 1) office-based convergence/ accommodative therapy with home reinforcement; 2) home-based pencil push-ups; 3) home-based computer program therapy (convergence/accommodative); 4) office-based therapy with no home reinforcement; 5) placebo vergence/accommodative treatment; 6) base-in prism reading glasses; and 7) placebo reading glasses. When the trials defined success as an outcome requiring both clinical measures of convergence to be normal, and also showed a pre-specified degree of improvement, they found high-certainty evidence that office-based treatment with home reinforcement increases the chance for a successful outcome compared to home-based computer treatment, home pencil push-ups and placebo treatment.

When success was defined as composite convergence and symptom success outcome, they found moderate certainty evidence that office-based vergence/accommodative treatment would give more successful outcomes than placebo treatment (Scheiman et al., 2020). Since not all studies included composite success data, they could not conduct network meta-analysis for treatment success. They were limited to comparing the mean difference between the different interventions for improving NPC, PFV and CISS scores using the data from three randomized controlled trials (RCT). Office based treatment was relatively more effective than placebo treatment in improving PFV but no evidence of a difference for NPC and CISS.

It has been shown long ago that exophoria at near (as well as other conditions such as vertical phoria, anisometropia, and aniseikonia) is associated with below-average reading performance (Simons & Gassler,1988). A review done by Simons and Grisham (1987) evaluates the relationship between binocular anomalies and reading problems. The evidence supports a positive relationship between reading problems and binocular anomalies such as exophoria at near, anisometropia, convergence insufficiency, and fusional vergence reserves. Exophoria at near showed a weak positive relationship to reading problems.

Exophoria can make reading at a near distance a harder task, making reading much slower. Prisms are a treatment for exophores; therefore, prisms should make reading easier, more comfortable, and faster. The aim of this study is to examine reading speed in subjects with exophoria while comparing the reading with prisms according to associated phoria tests and dissociated phoria tests.

When a patient with exophoria comes into the optometrist's office for an eye exam, it is crucial to address all difficulties. One of the main problems is reading at a near distance. A known treatment for this condition is prescribing prisms, but there are different approaches to the most accurate method of prescribing these prisms (Barden, 2021). Research conducted in Iran studied the effect of BI prism treatment on patients with Convergence Insufficiency (CI) (with greater exophoria at near than distance). This study found that prescribing BI prisms for patients with CI significantly decreased the symptoms related to near distance work and reading (Nabovati et al., 2019). In a study by Teitelbaum (2009), the effect of BI prisms was studied on presbyopic adults with Convergence Insufficiency. This study's results also showed an improvement in vision-related symptoms in the group treated with BI prisms (Teitelbaum et al., 2009). Scheiman et al. (2005) studied the effect of BI prism treatment in children ages 9-18 with symptoms due to CI. His study did not show a significant difference between the study group and the placebo group, although both groups showed an improvement in near vision-related symptoms (Scheiman et al., 2005). In Scheiman and Wick (1994), it is assumed that the best way to determine prism correction is by using Fixation Disparity under associated conditions since other methods will yield a higher amount of prism.

Associated phoria is measured under more natural conditions and therefore should predict the more comfortable prism correction. However, the correct method for prescribing prisms has not been researched much, and there seems to be no official approach. Although it was shown previously that both associated and dissociated phoria measurements can predict the comfortable prism (Scheiman et al., 2011). Jenkins et al. (1989) found that associated phoria can predict the more accurate prism since the asthenopic complaints are significant, whereas the complaints with dissociated phoria are not significant. Kromeier et al. (2002) studied the correlation between associated phoria and dissociated phoria and found that there is a high correlation between the two and no significant differences in the results of the procedures. The results were explained according to the theory that the accommodative demand was equal between the two procedures. They assume that previous studies showing differences between associated and dissociated phoria are due to different accommodative stimuli (Kromier et al., 2002).

When a large exophoria is found at near, it is one of the primary criteria for the diagnosis of convergence insufficiency, where the eyes tend to drift outwards instead of converging for near work. This condition has been found to affect reading adversely. Convergence insufficiency makes reading very difficult and patients will suffer from eye strain, double vision, slow reading, and reduced ability to read for long periods of time (Scheiman et al., 2011).

There are two different approaches when measuring phoria at near. One is associated phoria and the other is dissociated phoria.

Associated phoria is when both eyes are open and in natural conditions. It is the deviation of the binocular system under prism correction of fixation disparity. Fixation disparity is when the eyes are fused without having bifoveal correspondence due to phoric deviation (Otto et al., 2008). Associated phoria is tested with the Mallett Unit fixation disparity test (Karania & Evans, 2006) and other similar tests.

Dissociated phoria is the fusion of the visual system when only one eye is fixating, showing the eye's natural deviation (Brodsky et al., 2005; Sanker et al., 2012). Testing this will give us the deviation from the orthovergence position (Barden, 2021). There are a few dissociated phoria tests at near: Maddox Rod, von Graefe and alternate cover test with the modified Thorington test (Schroeder et al., 1996). The results of these tests will be different (usually higher prism value) than the associated phoria test.

This study compares the fixation disparity test for associated phoria, and the Maddox rod test for

dissociated phoria and the effect on reading speed.

The Maddox Rod test is performed by placing the Maddox lens horizontally in front of the right eye. The patient is shown a light at 40cm so he or she will see the light and a streak at the horizontal axis. The distance between the streak and the light is neutralized using a prism bar (Gantz & Stiebel-Kalish, 2021).

Fixation disparity will be tested using the Shapiro-Evans Diagnostic Occluder Set (Shapiro, 2000). The occluder presents a red and green line separated by a central lock. The patient wears red/green filters and is instructed to comment on how he sees the lines. If the lines are not aligned, the prism bar will be used to measure the amount of prism needed to align them.

Reading speed will be tested with the International reading speed texts (IReST). This is a standardized text assessment of reading in different languages. It can be used to compare reading before and after intervention. This textbook contains standardized paragraphs in different languages used to assess reading speed. These texts are recommended due to the fact that a paragraph can give us more information on reading speed than a single sentence (Trauzettel-Klosinski et al., 2012).

2. Hypothesis

Dissociated phoria is usually larger due to the fact that the eyes are not fused at the time of the measurement, allowing the eye to assume a more distant location without the binocular stress. It is assumed the reading speed will improve with the prismatic correction of the phoria in both trial groups. Additionally, since the dissociated phoria is larger and therefore the prism given is larger, a larger effect in the dissociated phoria is expected. On the other hand, the larger the prismatic correction, the more aberrations that are present, so there may not be a significant difference between the two corrections. It is also assumed that compared to no correction, the patients will describe more comfort of reading with the prismatic correction compared to uncorrected reading.

3. Methods

An experimental study was conducted using an experimental group and a control group of patients recruited from an optometrist's clinic in Israel. The study included 30 participants (aged 8-18); 15 in the experimental group and 15 in the control group (eight men and seven women in the study group and seven men and eight women in the control group), all randomly selected. All patients were diagnosed by an experienced optometrist with exophoria above normal at near (>4 prism diopter). The criteria recommended by the Optometric Extension Programme (OEP) norm data table, that exophoria above 4 diopters is abnormal, was used (Scheiman & Wick, 1977).

Exclusion criteria: subjects with diplopia, suppression, or reduced visual acuity (VA < 0.1) were excluded from this study, seeing that these cases can all have a strong adverse effect on reading in general and reading speed specifically. All phoria testing was conducted after full refraction was done and the subject was wearing full Rx.

3.1. Tools:

Reading test: for testing reading speed, the IReST (international reading speed test) was utilized. Each one of the three tests used a different text (on the same reading level) from the textbook. Reading speed was calculated by words per minute: words read correctly/reading timeX60, according to the textbook

instructions. The text used was in Hebrew and each subject read different texts on the same reading level.

Fixation disparity: Fixation disparity was tested using the Shapiro-Evans Perceptions occluder set (O'Donnel, 2000). The Shapiro-Evans Diagnostic occluder is an occluder with different vision tests. The one that was used is fixation disparity using two lines, one red and one green, that the subject aligns using a prism bar.

Maddox Rod dissociated phoria test: Maddox rod lens and flashlight were used (Dolman,1919). The Maddox rod lens is a red lens made of a series of parallel glass rods that convert a light source into a streak of light. The position of the light streak measures the phoria using a prism bar.

3.2. Procedure:

All subjects in both groups underwent a comprehensive eye exam by an experienced optometrist. Eye exams included full refraction, binocular alignment at near and far, versions evaluation, accommodative amplitude, near point of convergence, and an ophthalmoscope evaluation.

Based on results of the eye exam, patients were recruited to participate in research and placed in the research or control group according to the criteria described above.

Experimental Group

The experimental group was rechecked for near measurement of exophoria.
Near Exophoria Exam: first, associated phoria was measured using fixation disparity test. The subject wore red/green glasses and was presented with an image of two vertical lines (one red and one green) divided by a white OXO. Using a prism bar, the instructor measured the amount of prism needed to align the red and green lines in order to get a normal deviation.

The next test measured dissociated phoria using the Maddox Rod test. The Maddox Rod lens was placed in front of the subject's right eye horizontally and a light source (flashlight) was placed at 33cm from the subject. Using the prism bar, the amount of prism it takes to bring the streak of light to be aligned with the light source was measured.

Once the two prism measurements were established, the subject read the text three times: once with full Rx correction and no prisms, then using the prism measured with the fixation disparity test, and another time using the prism measured with the Maddox rod test.

After the subject read each of the three texts and reading speed was measured, the subject responded to a questionnaire giving an indication of subjective feelings during each test. After reading each text, the subject was asked to rate comfort while reading. The responses were based on a 1-10 scale with 1 being least comfortable and 10 being most comfortable. This indicated the patient's comfort while reading, which would be related to reading speed (if the subject is comfortable, reading should be easier and faster).

Control Group

The control group read the text three times with full Rx and no prisms, each time reading a different text on the same reading level (the same three texts that the experimental group used). The subjects in the control group answered the same questionnaire to rate reading comfort as the study group on a scale of 1-10.

4. Results

Thirty subjects were tested, ages 8-18 (average age for control group 11.53+-2.97 and average age for study group was 11.46+-3.09) and evenly split by gender with 15 males and 15 females. No significant

differences were present in age or gender between the research group and the control group (p=0.47 for age and p=0.36 for gender).

The average reading time between reading with prism correction (according to Maddox Rod and Fixation Disparity) and without prism correction was not significantly different (p=0.240, p=0.117). The average time between reading with prism correction according to Maddox Rod test and prism correction according to Fixation Disparity also showed no significant difference (p=0.39).

Reading speed with no prisms in the research group was not significantly different compared to reading speed in the control group with no prisms (p=0.397, p=0.37, p=0.48).

Subjectively, patients were more comfortable reading with prisms, with the research group showing a trend toward slightly faster reading with prism correction compared to no prism in the control group (see figure 1). According to the questionnaire asking the subject to rate reading comfort after each text using a 1-10 scale (10 being most comfortable), it was indicated that when subjects rated reading comfort as most comfortable, they were reading with prisms according to fixation disparity (9 +/- 1). Subjects in the control group were less comfortable while reading the third text (7.8 +/- 0.86), possibly due to discomfort after reading for a while (see figure 2).

Average reading speed in the research group was 66.33 (+/- 13.906) seconds with no prisms, 60.4 (+/-12.78) seconds with prisms according to fixation disparity, and 62.8 (+/-13.22) seconds with prisms according to Maddox Rod. This shows a trend towards faster reading with prisms according to fixation disparity.

In the control group, the average reading speed for the first text was 65.067 (+/-12.45), for the second text was 64.867 (+/-11.23), and for the third text was 66.2 (+/-11.11).

When comparing the results of the subjective questionnaire regarding reading comfort in the control group, no significant difference was found between the first, second, and third time reading (p=0.08, p=0.36, p=0.11). In the research group, the results did show significance between reading with no prisms and reading with prisms according to fixation disparity (p=0.003). A significant difference was also shown between reading with prisms according to Maddox Rod and prism according to fixation disparity (p=0.02). No significance was shown between reading with no prism and reading with prisms according to Maddox Rod (p=0.15).

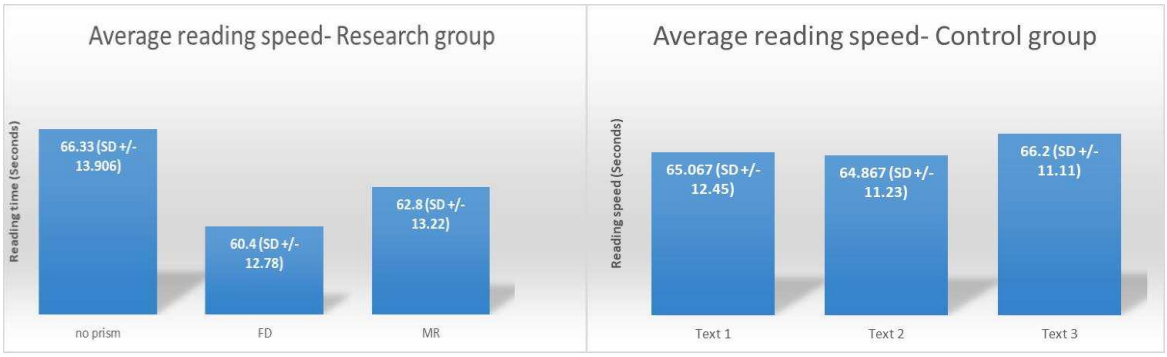

Figure 1. Average reading speed in research group and control group. (a) control group. (b) research group

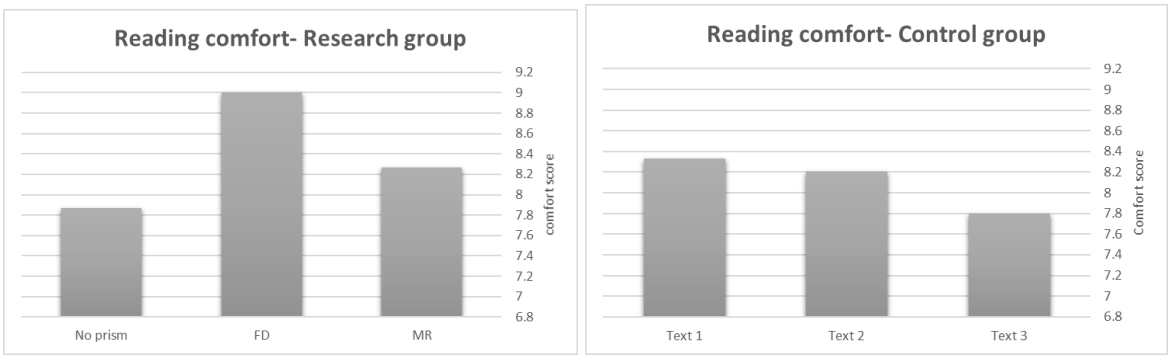

Figure 2. Reading comfort according to a subjective questionnaire after reading each text. (a) Research group. (b) Control group

5. Discussion

Evidence shows that exophoria at near (or convergence insufficiency in severe cases) reduces time spent reading, probably due to difficulty while reading (Nisted et al., 2019). A survey done by Egelund (2007) showed a positive correlation between hours of reading and reading speed (among other things).

The gold standard for treatment of convergence insufficiency is office-based vision therapy treatment (Scheiman et al., 2020), but not all patients can afford it or have the time needed to properly do it. A large percentage of the population in Israel cannot afford vision therapy as it is not recognized by the local insurance companies. Additionally, the primary vision care providers do not offer vision therapy. It is necessary to have another option for treatment to provide these patients when vision therapy is not available. An alternative option of treatment discussed in the literature is base-in prisms. This mode of therapy has been found to alleviate some of the symptoms in some cases of convergence insufficiency (Stavis et al., 2002). However, one of the other studies found no significant difference in quality of reading when prescribing base-in prisms for exophoria (Scheiman et al., 2020).

In the analysis of the results, a trend was found towards faster reading and more comfortable reading while wearing base-in prism reading glasses (more so with prisms prescribed according to fixation disparity testing than Maddox Rod test). This discrepancy in the findings may be explained as a placebo effect, or alternatively, it may also be explained by the different modes of testing, as well as the different subjects and sample size. Further research should be conducted to find more significant results and to get a better understanding of treatment options.

One of the ways to treat exophoria is by prescribing corrective glasses with base-in prisms. The prisms help align the images viewed so that the eyes don't have to strain to see single and clear images (Barden, 2021). The amount of prism needed to align the eyes can be determined using dissociated phoria testing (the amount of deviation from orthophoria) or associated phoria testing (the amount of prism used to nullify fixation disparity under natural conditions) (Otto et al., 2008).

Even though associated phoria and dissociated phoria are known to give good prism correction to eliminate asthenopia and other difficulties due to exophoria (Sheedy & Saladin, 1978; Alvarez, 2015), different studies showed that associated phoria would give the more comfortable prism (Jaschinski, 2002).

In this study, this conflict was revisited, comparing reading speed according to dissociated phoria (Maddox Rod) and associated phoria (fixation disparity).

The results of this study did not show a significant difference between the tests (reading speed with prisms according to Maddox Rod test and according to fixation disparity), but a trend towards faster and more

comfortable reading with prisms prescribed using fixation disparity was indicated, according to the subjective questionnaire that the subjects answered after reading the text. Not only was there a trend towards reading with prisms according to fixation disparity, but there was a significant difference when comparing FD results to reading with no prisms and compared to reading with prims according to Maddox Rod.

One can try to explain these results in a few ways. First, high prisms have an optic effect of distortions and visual confusion, loss of visual field and sometimes diplopia (Jung & Peli, 2014). This can cause difficulty while reading for different reasons than the difficulty caused by exophoria, which can bring about slower reading.

Second, the text that was used to test reading speed (IReST) may have been too short. It is more difficult to read a longer text and that is when people with exophoria would most likely feel the difficulty reading and perhaps read more slowly. Subjects may also lose their attention span after all the vision testing and reading a few texts, and therefore read slower while reading the third text.

Third, the research group may have been too small. Thirty subjects were tested (n=30) and a larger number of subjects in the study would likely lead to more significant results.

Another element that was not discussed is accommodation; the eye's ability to change focus by a change in the eye's dioptric power, when looking at a near image (Glasser, 2008). The ability to accommodate and the accommodation flexibility have a great impact on any near work, including reading. Any accommodative dysfunction would greatly affect the results of a reading test. In normal cases, accommodation problems start after the age of 40 in presbyopes. In this study, the age group was 8-18, so testing accommodation was not necessary. However, there are cases where children also suffer from accommodative insufficiency or accommodative infacility, and in either of these cases the reading speed would be adversely affected. In further research, perhaps accommodation should be tested and any subjects with accommodative dysfunctions should be excluded from the study.

This study was randomized, but the order in which the three texts were read was the same for all subjects. The subjects in all cases first read the text with no prisms, then read the text with prisms according to fixation disparity test and the third text was read with prisms according to Maddox Rod test. It may be that the subject suffered eye strain and fatigue by the time they got to reading the third text and this would explain the subjective feeling that reading the third text (according to Maddox Rod) was less comfortable than reading the text with prisms according to Fixation Disparity. I would recommend retesting this in future studies with a full randomized trial, having a group of subjects start with no prisms, another group start with prisms according to Fixation Disparity and, finally, a group starting with prisms according to Maddox Rod.

In summary, given the limitations of this study, future research on this topic may benefit from a larger sample size. Also, utilizing longer texts and allowing subjects to have a brief rest period between testing and reading the three texts to reduce fatigue may generate more significant results. Excluding patients with very high exophoria so as not to get the optic effect of high prisms may also improve the results.

While the hypothesis was not supported, there was evidence that subjects felt reading was more comfortable with prisms prescribed using Fixation Disparity. This suggests that optometrists may be more successful using associated phoria testing (such as Fixation Disparity) when prescribing prisms in order to give their patients a better quality of life. Another option for further research would be to measure the comfortable prism between the amount determined by associated phoria and the amount determined by dissociated phoria.

The results of this study support the previous literature showing that there is a correlation between associated phoria testing and dissociated phoria testing, since no significant preference to one or the other was found. The subjective rating of the comfortable prism for reading supports the previous literature showing that associated phoria and fixation disparity, under natural conditions, give the more accurate and comfortable prism.

6. Conclusion

There are many problems that can affect reading, and specifically reading speed. One of these problems is exophoria. When the eyes are in an exophoric state, smooth and full convergence is harder to achieve, making reading more difficult and therefore slower. In order to make reading easier, base-in prism glasses can be prescribed.

Phoria can be measured in different ways, resulting in different amounts of prisms that can correct the phoria and help the symptoms. There are tests that measure associated phoria and tests to measure dissociated phoria. In this paper, we compared reading speed using prisms prescribed according to associated phoria tests and prisms prescribed according to dissociated phoria tests.

Dissociated phoria gives a larger prism than associated phoria; therefore, it is assumed that the prism according to dissociated phoria tests will give faster reading. Although, both prisms prescribed (according to associated phoria and dissociated phoria) should result with faster reading compared to no prism at all in patients with exophoria.

The results of this research showed no significant difference in reading speed between the two groups. A trend towards faster reading with prisms prescribed according to associated phoria was found. In addition, results of a subjective questionnaire that the subjects responded to suggests that reading was more comfortable with prisms according to associated phoria testing (fixation disparity).

It is important to note that, while this paper focuses on reading speed and reading comfort, there are other measures of quality of reading that were not addressed in this paper. In this context, it should be noted that different reading purposes require different reading speeds, and that reading speed without comprehension is worthless (Bell, 2001). Further research on the effects of exophoria on reading comprehension and quality of reading should be conducted in order to get a broader picture and better guidelines for evidence-based practice in cases of exophoria.

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