THE EFFECT OF INDUCED VERTICAL PRISM ON READNG RELATED PARAMETERS IN NORMAL SUBJECTS

by

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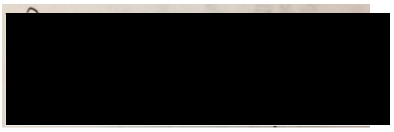

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Date: March 12th, 2017

ABSTRACT

Background: The study evaluated the effect of induced vertical prism on reading efficiency, speed, and comprehension in a group of young adults. Reading efficiency, speed, and comprehension were evaluated using The Visagraph 3 which provides an objective measurement of ocular movements as the subject reads through a paragraph. Vertical deviations were induced by introducing prisms before one eye after controlling for any natural heterophoria.

Methodology: A sample of students (N=46) between the ages of 21-30 were included. All subjects were initially screened with a Modified Thorington test to elicit any vertical phorias. If a vertical phoria was present, correcting prism was given to neutralize the phoria. Visagraph testing then ensued with induced prismatic powers of the following strengths: 0 PD, 1 PD, 2 PD & 3 PD (or the prism of highest magnitude which does not disrupt fusion). Testing was randomized to minimize the effects of fatigue and learning.

Results: We found vertically induced prism caused significant differences on the following reading related parameters: fixations, reading speed, and grade level equivalent.

Conclusion: We found that vertically induced prism caused significant differences on the following reading related parameters – a) Fixations, b) Reading Speed, c) GLE. These differences could be the effect of the increased vertical vergence demand created by the induction of prism and could have clinical implications for prismatic prescribing practices. However, we cannot discount the effect of confounding variables such as subject psychology, criterion, and familiarity with content – all of which may have influenced our results.

Acknowledgements

We would like to thank our research advisor, Dr. Vandana Rajaram, for all the time and effort she placed into this project. We also would like to thank Dr. Avesh Raghunandan for his valuable input to this research.

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CHAPTER 1

INTRODUCTION -

Vertical heterophoria is a condition in which the visual axis of one eye falls above that of the fellow eye at physiological rest.[1] Throughout the years, many studies have validated a correlation between vertical heterophorias and reading related difficulties along with other symptoms including asthenopia, diplopia, drowsiness, fatigue, nausea and motion sickness.[2] With approximately 10-35% of the population having a vertical heterophoria of 0.5 prism diopters or greater, the prescribing of vertical prismatic correction is likely a task that will befall every practicing eye care provider.[2] While many methods exist for prescribing such corrections, and largely depend on symptomatology of individual patients, there is very little in the literature that addresses the question of the magnitude of deviation at which patients typically become symptomatic . The purpose of the following study was to attempt to shed light on this question. This was done through the objective evaluation of the effect of induced vertical prism on reading efficiency, speed and comprehension in normal adults with no known history of reading deficits. Despite inherent differences between physiological and artificially induced vertical heterophoria, there is knowledge to be gained by studying induced vertical heterophoria in a physiologically orthophoric population. The following study will discuss the effect of induced vertical ocular deviation on reading related parameters in normal subjects.

CHAPTER 2

METHODOLOGY -

The study included forty-six subjects in the age range of 21-30 years with no known binocular vision or reading-related abnormalities. The Visagraph III eye movement recording system was utilized to measure the following reading related parameters – a) Fixations, b) Regressions, c) Speed, d) Comprehension, and e) Grade Level Equivalent (GLE). This system uses goggles with built-in infrared sensors that track eye movements while the subject reads a paragraph. Four measurements were conducted over a span of approximately 30 minutes with varying induced vertical prisms of the following strengths: 1 Prism Diopter (PD), 2PD, 3PD, and zero prism as a baseline condition. The subjects were screened via Modified Thorington to identify any pre-existing vertical deviations. If the subjects had a natural vertical phoria, they were neutralized with prismatic correction prior to testing. Additional prisms were then placed over the right eye, in front of the goggles to induce deviation. Subjects were instructed to silently read each paragraph as quickly and as accurately as possible. The book containing the reading excerpts was placed flat on a table surface in front of each subject. All subjects were administered a 10 question reading comprehension test following the recording. The amount of vertical prism induced and the correlating paragraph in which they were required to read are described in the following table (table 1).

Trial	Sequence	Content
1	2 PD	Frank Lloyd Wright
2	1PD	Sir Earnest Shackleton
3	3PD	Clara Barton
4	0 PD/Baseline	Henry David Thoreau

CHAPTER 3

RESULTS -

The Mean and Standard Error of Mean (SEM) for each reading parameter were computed. Data from trials where comprehension was below the criterion[3] of 70% were excluded from the statistical analysis. Means of each reading parameter, for different prism strengths, were analyzed using a single factor Analysis of Variance (ANOVA). The results were statistically significant for Fixations ($F(3,161) = 5.04$, $p = 0.002$), Reading Speed ($F(3,160) = 4.86$, $p = 0.002$) and GLE ($F(3,160) = 5.27$, $p = 0.001$) and non-significant for Comprehension ($F(3,163) = 2.27$, $p = 0.08$) and Regressions ($F(3,150) = 1.69$, $p = 0.17$).

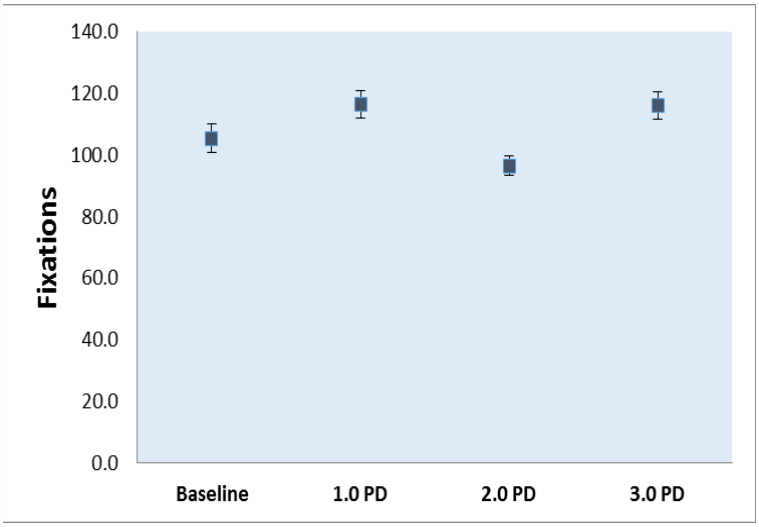

Table 2: Mean Fixations at 2 PD were significantly lower ($p < 0.01$) in comparison to 1PD and 3 PD. Mean fixations at baseline were also significantly lower ($p < 0.04$) compared to 1 PD and 3 PD.

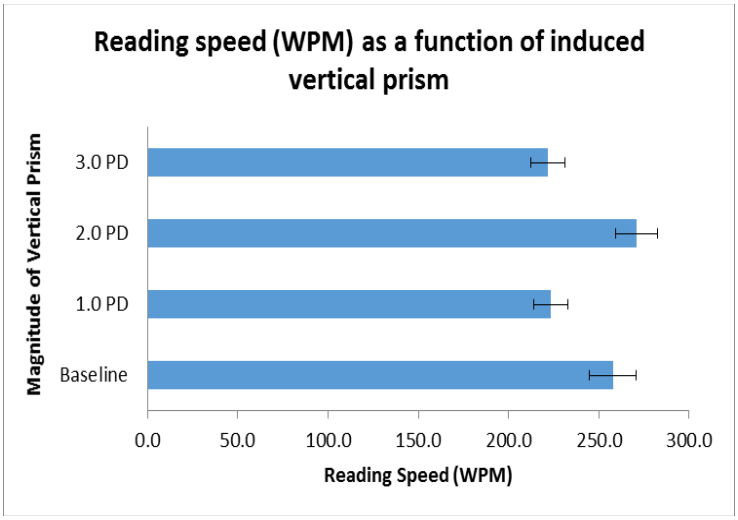

Table 3: Mean Reading Speed at 2 PD was significantly higher compared to that at 1 PD ($p < 0.002$) and 3 PD ($p < 0.001$). Mean reading speed at baseline was also significantly higher compared to 1 PD ($p < 0.04$) and 3 PD ($p < 0.02$).

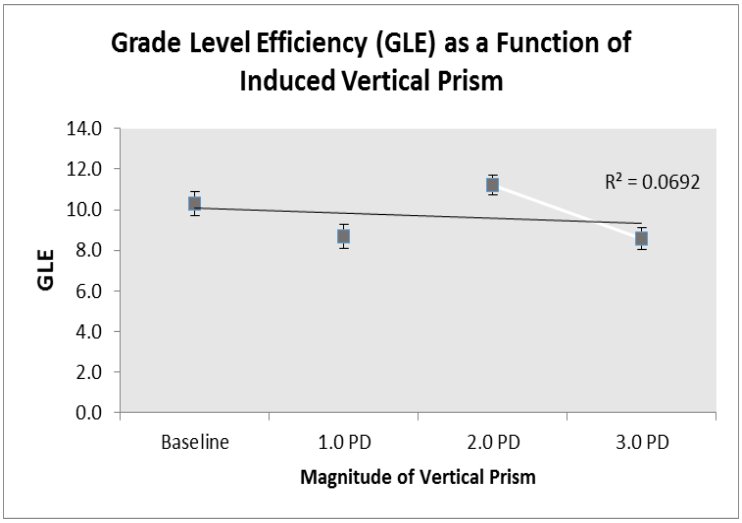

Table 4: Mean GLE at 2 PD was significantly higher compared to that at 1 PD ($p < 0.001$) and 3 PD ($p < 0.001$). Mean GLE at baseline was significantly higher compared to that at 3 PD ($p < 0.03$).

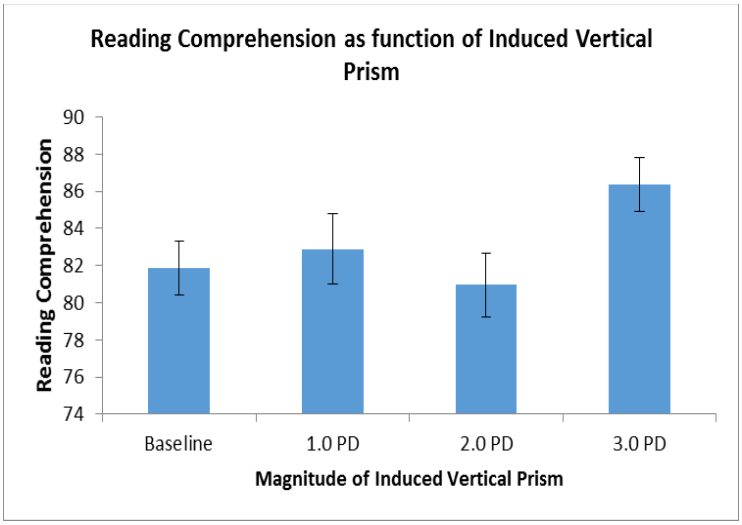

Table 5: Mean Reading comprehension was non-significant in the overall analysis ($p = 0.08$), but mean comprehension at 3 PD was significantly higher compared to baseline ($t = 2.18$, $p < 0.03$; two tailed); 1 PD ($t = 2.68$, $p < 0.01$; two tailed) and 2 PD ($t = 2.91$, $p < 0.005$; two tailed)

CHAPTER 4

DISCUSSION -

Our initial hypothesis stated that as the amount of induced vertical prism increased, there would be a concurrent increase in fixations and a corresponding decrease in GLE, reading speed, and comprehension. After data analysis was conducted, our results showed significantly lower fixations and higher reading speed and GLE for the zero prism (or baseline) condition. As stated in our introduction, literature suggests a strong correlation between uncorrected vertical phorias and poor reading performance.[4] Despite this evidence, a more recent study showed that induced horizontal or vertical prisms do not influence reading performance.[5] One could assume that our results reflect stress on the vergence system caused by the increased vertical vergence demand. However, the aforementioned study[5] also concluded that artificially inducing a vertical deviation

does not pose the same stress to the vergence system as a natural vertical phoria would. Additionally, one has to factor in the effects of prism adaptation across trials which may have influenced our results.[5,6] The fascinating part about this study is that subjects demonstrated better performance on many reading parameters for the 2 PD condition. We believe this is attributed to the testing sequence as all subjects started with the 2 PD condition. Additionally, all of our subjects were optometry students and the majority were aware of the parameters of the Visagraph III as well as the purpose of the testing. There is anecdotal evidence that our sample conceives reading ability as a measure of intelligence. Due to this, we speculate that they were motivated to give their best performance for this condition, so they would not look un-intelligent in front of their peers. This manifested as enhanced reading performance for the first trial. As subjects relaxed throughout the course of testing, this motivation may have dwindled, compromising performance.

Despite the lack of *overall* differences in the reading comprehension scores between the different prism conditions, comprehension scores were significantly higher - specifically for the 3 PD condition. We attribute this finding to familiarity with the content of the text read for this condition as many schools teach about Clara Barton as part of their curriculum. Due to the subject's prior knowledge of the content, we believe this artificially increased the reading comprehension score for the 3PD measurement.

In conclusion, we found that vertically induced prism caused significant differences on the following reading-related parameters – a) Fixations, b) Reading Speed, c) GLE. Although results were likely confounded by the influence of patient psychology, bias and former knowledge, these differences could be in part the effect of increased vertical vergence demand created by the

induction of prism. With study modification and additional experimentation, results could ultimately have clinical implications for prismatic prescribing practices.

If we were ever to perform this study again, we would spread testing over a span of four days, having each subject run one trial per day, thus decreasing the chance of diminishing motivation as a muddying variable in the testing results. We also would randomize the prism diopter value and text for each subject to eliminate any false high/low data which was likely experienced with the 3PD and Clara Barton trial. Due to the high prevalence of vertical heterophoria in the general population, additional studies targeted at quantifying typical symptomatic levels should be conducted to add to the current literature. With enough scientific study, future prismatic prescribing practices could be influenced.

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APPENDIX A

IRB APPROVAL FORM

Ferris State University

Institutional Review Board (FSU - IRB)
Chair
820 Campus Drive
Ferris State University
Big Rapids. MI 49307
(231) 591-2759
IRB@ferris.edu

Date: April 25, 2016
To: Dr. Vandana Rajaram, Samantha Gagnon and Andrea Shank
From: Dr. Gregory Wellman, IRB Chair
Re: IRB Application #160307 (Effect of Uncorrected Vertical Deviations on Reading Speed, Efficiency and Comprehension)

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, "Effect of Uncorrected Vertical Deviations on Reading Speed, Efficiency and Comprehension" (#160307) and determined that it meets Federal Regulations Expedited-category 2D/2F. This approval has an expiration of one year from the date of this letter. **As such, you may collect data according to the procedures outlined in your application until April 25, 2017.** Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#160307), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

Understand that informed consent is a process beginning with a description of the study and participant rights with assurance of participant understanding, followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document and investigators maintain consent records for a minimum of three years.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

Ferris State University Institutional Review Board Office of Research and Sponsored Programs