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### Vision training: Does the incorporation of jumping on a trampoline increase the effectivity of vergence range building during vectographic training?

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## Vision training: Does the incorporation of jumping on a trampoline increase the effectivity of vergence range building during vectographic training?

### Abstract

The purpose of this study was to examine the effects of vectographic training on vergence ranges and to determine whether incorporation of trampoline jumping would potentiate vergence range building . Thirty-four subjects were randomly divided into three groups. The two experimental groups, one standing the other jumping on a trampoline, received 12 sessions of vectographic training. Phorias and vergence ranges were measured for all three groups, including a control group who received no training, before, after, and three months following the training period. After completing three total hours of training there was no significant difference in the increased ranges between the two experimental groups, or three months later. However, both experimental groups had significantly increased their vergence ranges compared to the control group. In addition we found that training had a greater effect on results at 40cm than at 6m, there was a greater change in the convergence ranges than the divergence ranges, and recoveries for the trampoline group at far increased significantly.

### Degree Type

Thesis

### Degree Name

Master of Science in Vision Science

### Committee Chair

Hannu R. V. Laukkanen

### Subject Categories

Optometry

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**VISION TRAINING:  
DOES THE INCORPORATION OF JUMPING ON A TRAMPOLINE  
INCREASE THE EFFECTIVITY OF VERGENCE RANGE BUILDING  
DURING VECTOGRAPHIC TRAINING?**

**By**

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Theresa A. Mehary  
Steve F. Schiffelbein**

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Advisors:

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Harold M. Haynes, OD**

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## **Abstract**

The purpose of this study was to examine the effects of vectographic training on vergence ranges and to determine whether incorporation of trampoline jumping would potentiate vergence range building. Thirty-four subjects were randomly divided into three groups. The two experimental groups, one standing the other jumping on a trampoline, received 12 sessions of vectographic training. Phorias and vergence ranges were measured for all three groups, including a control group who received no training, before, after, and three months following the training period. After completing three total hours of training there was no significant difference in the increased ranges between the two experimental groups, or three months later. However, both experimental groups had significantly increased their vergence ranges compared to the control group. In addition we found that training had a greater effect on results at 40cm than at 6m, there was a greater change in the convergence ranges than the divergence ranges, and recoveries for the trampoline group at far increased significantly.

## Introduction

To what extent is visual behavior subject to "learning" or modification by interactions with the environment, specific training, or practice effects? As early as the eighteenth century, researchers studying the visual system have postulated that binocular vision is a learned response. Hofstetter<sup>1</sup>, in 1945, reviewed the history of binocular vision relative to the zone of single binocular vision (ZSBV). He found that in 1759, Porterfield had stated that the relationship between accommodation and convergence is learned through "use and custom." According to Hofstetter, the first clinical investigation of this concept was by Howe<sup>2</sup> in 1900. Howe had two subjects--for one subject, he prescribed rest for his asthenopia, and for the other subject, the use of exercises to adapt the patient to his needs and a possible change in vocation to alleviate his visual task. Roelofs<sup>3</sup>, in 1913, concluded that with exercise and patience, one can attain the same degrees of divergence at all levels of accommodation and, vice versa, one can attain the same degrees of accommodation at all degrees of divergence. Maddox<sup>4</sup> stated that vergence ranges and binocularity are educated processes and are therefore modifiable, amplifying Porterfield's concept. In 1937, in a series of papers, Crow and Fuog<sup>5</sup> stated that the basic principles behind orthoptics are for "reconditioning binocular motor integrations." All of the researchers seemed to agree with the concept that the accommodative and vergence movements are subject of the practice effect and that they can be modified through training.



One of the major goals of optometric vision training is the improvement of visual subskills that contribute to comfortable, binocular vision. The zone of single binocular vision (ZSBV) may describe this area of "comfortable vision." It is defined or limited by the ranges of convergence and divergence measured phorometrically. The lines connecting the divergence and convergence breaks represent the limits of single, but not necessarily clear, binocular vision.<sup>6</sup> The narrower this zone of "comfortable vision", the greater the likelihood of asthenopic complaints.<sup>7</sup> In theory, if the zone could be widened, asthenopic complaints could be eliminated. In conventional optometric theory, one way to expand the zone is through vision training procedures devoted to expanding the vergence range.

Vergence range building is important in many aspects of vision training, yet little research has been done comparing the efficacy of range building methods. Clinical observations suggest that lateral vergence ranges expand at a faster rate when standard vergence building activities are combined with trampoline jumping. Jumping on a trampoline challenges several physiological systems to work simultaneously, in conjunction with the visual system. Integration of major muscle groups, postural awareness, attention, vestibular input, compensatory eye movements, and motor and sensory fusion all must be coordinated if binocularity is to be maintained. From clinical impressions, we hypothesized that the utilization of a trampoline would increase training efficacy. The purpose of our study is to determine whether trampoline jumping during vergence

building activities would increase the effectivity of the training in a clinical research environment.

### **Problems:**

In addition, this study was designed to answer the following questions: 1. Would the impact of vectographic training at two meters be greater for vergence range findings at far (6m) or at near (40cm)? 2. If vergence ranges do expand, would these changes be transient or represent long-term behavioral changes? 3. Would changes be more significant for divergence ranges or convergence ranges? 4. Would breaks or recoveries be more significantly changed? 5. Would the total magnitude of the absolute duction range from convergence to divergence expand or remain unchanged (e.g. expansion of convergence be matched with corresponding reduction in divergence)?

### **Methods**

Fifty two subjects from the undergraduate and optometry school population of Pacific University were solicited for this study. Subjects were accepted into the study if: 1) there was no evidence of strabismus, 2) they had inferior Convergence Index (Ci) Scores using Dr. Harold Haynes' Normative Analysis Criteria (see appendix A), 3) they demonstrated better than 100 arc seconds distance stereoacuity using an AO Vectographic Slide, and 4) they manifested less than one prism diopter vertical phoria as measured by a subjective cover test. Thirty four subjects passed the screening criteria and were randomly assigned to one of three groups: a control group and two experimental groups.

Phorias and lateral vergences were measured phorometrically for each subject in the study. The measurements were taken by four examiners not affiliated with the study in order to eliminate examiner bias. Each subject was examined by a designated examiner three times during the study: once prior to the training period, once immediately following the completion of training, and once three months after the completion of training. Phorias and vergences were measured three times for each subject during each examination and subsequently averaged to minimize measurement error.

The two experimental groups (N=11 each) received projected vectographic training utilizing polaroid glasses and standard vectographs consisting of Quoits, Mother Goose, Topper, Clown, Spirangle, and Chicago Skyline, available through the Bernell Company. Polaroid glasses have opposite polarizing filters in each ocular which allow one eye to see one half of the vectographic image while the other eye sees the other half. The subjects in the two experimental groups were required to participate in three training sessions per week for four weeks to total twelve sessions. Each training session was fifteen minutes in length, consisting of three minutes of vectographic training alternated with two minutes of rest. To maintain control of the experiment, subjects were not allowed to miss more than one session nor were they allowed to participate in any other visual training during the course of the study. Each subject in the training groups received an equal amount of exposure to each of the six vectographs. The vectographic image was projected onto a reflectorized screen by an overhead projector positioned six feet from the screen. The divergent and convergent

demand of the vectographic image was changed manually by one of the researchers. The researchers rotated between the two experimental groups throughout the course of training to minimize any bias that might be induced by a particular examiner. During the training period, the control group (N=12) received no training.

During the ninth session, bi-nasal occluders were incorporated to dissociate and disrupt convergent activity and further encourage the divergence range to expand. The bi-nasal occluders were created by placing opaque tape on the polaroid glasses from the binocular light reflex to the nasal border of the glasses. During the tenth and eleventh session, each participant used a polaroid flipper during the session. A polaroid flipper is a hand held device with four oculars and polaroid filters in each ocular. These polarizing filters are oriented in order to change the vergence demand, from convergence to divergence, as the flipper is "flipped" from one set of oculars to the other set. These flippers were incorporated to enhance the training by rapidly requiring the subject to do "jump ductions" from a positive relative convergence demand to negative relative convergence demand. The vectographic image was set so that each participant could maintain fusion for both the divergent and convergent demands. To further increase the demand of training, the twelfth session included loose Base-In prisms attached to the polaroid glasses to start the participant at a divergent posture and stimulate vergence range expansion from a divergent posture. The amount of base-in prism used for each subject was two prism diopters less than their divergent recovery at six feet.

The first experimental group, the Static Group, trained in groups of four while standing and doing the training regimen described above. The second group, the Trampoline Group, trained in groups of two with each subject bouncing on their own mini-trampoline. The trampolines used were the standard 1 meter mini-trampolines widely available in sporting goods stores. It is important to note the main difference between the two experimental groups was the use of a trampoline while training for the Trampoline Group. A metronome was used to standardize the rate at which the subjects in the Trampoline Group jumped and to standardize the rate of vectographic disparation for both experimental groups.

## **Results**

A Convergence Index (Ci) Score was calculated for each subject before and after training. The Ci Score converts the vergence tests (lateral vergences & phorias) into a common metric using the Mac Intosh computer program version 1.3f of Normative Analysis by Haynes. A significant increase in the vergence ranges translates to an increase in the overall Ci Score. (For further explanation of Ci Scores, please refer to Appendix A.) A level of significance was set at  $\alpha = 0.05$  for all questions. An analysis of variance for each group between each of the three testing times was calculated for the three groups. Both experimental groups showed a significant increase in their Ci Scores from measurements taken before training to measurements taken immediately following training and to those taken three months following training.

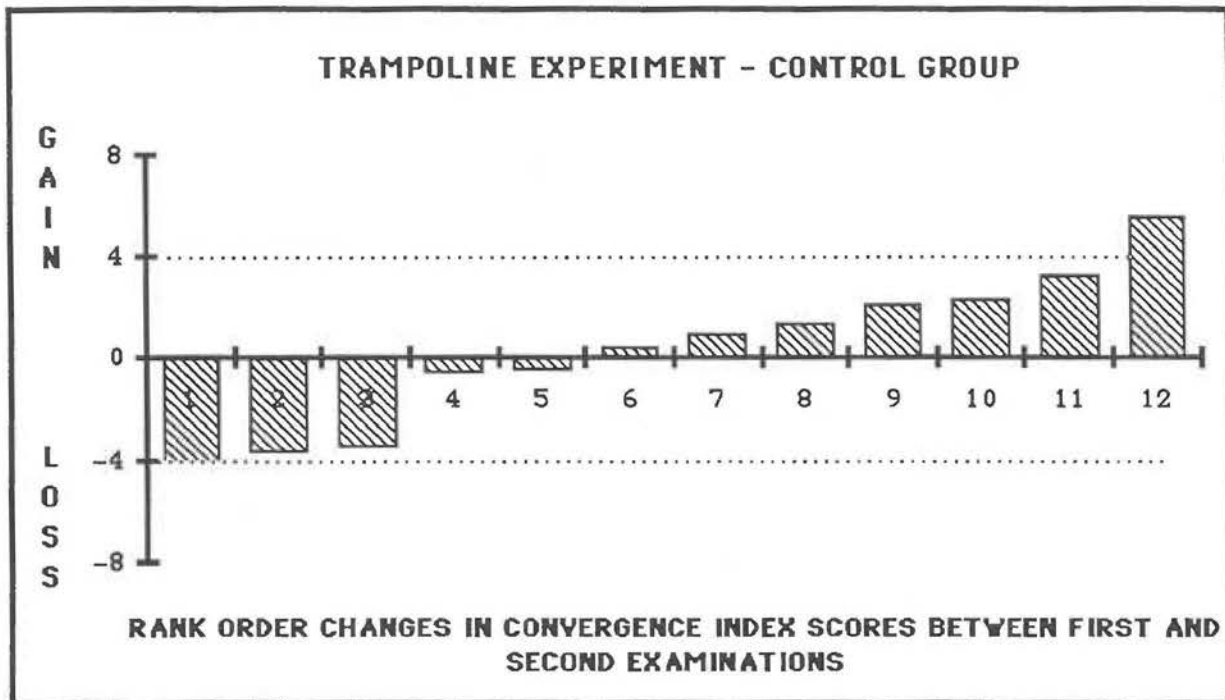


Figure 1. Ordinate Axis = Convergence Index Units    Abscissa Axis = Individual Subjects

Figure 1 shows the Ci Scores for the Control group. Five of the twelve Control subjects showed a decrease in Ci Score and seven showed an increase (as much as 6 units), with a mean gain of 0.32 Ci units and a standard deviation of 2.97. This change was not statistically significant.

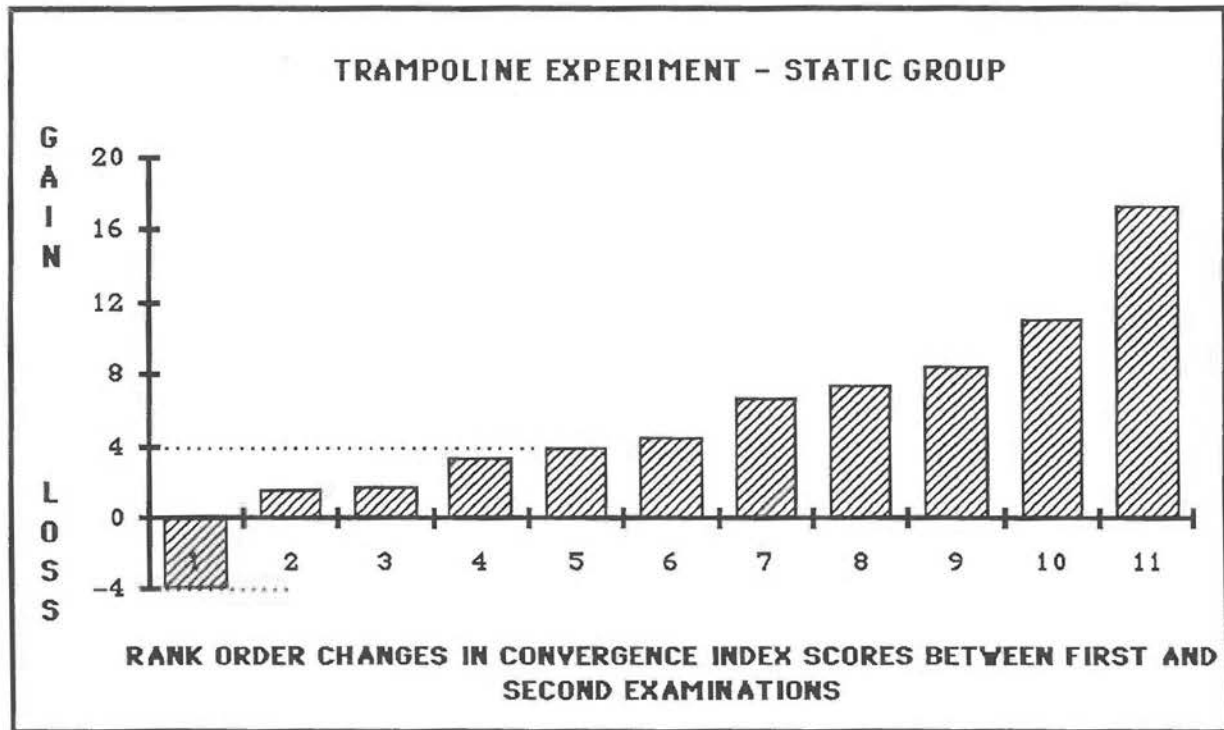


Figure 2. Ordinate Axis = Convergence Index Units    Abscissa Axis = Individual Subjects

Figure 2 shows the Ci Scores for the Static training group. Ten of eleven Static subjects gained in Ci units, with an overall mean gain of 5.67 Ci units and a standard deviation of 5.56.

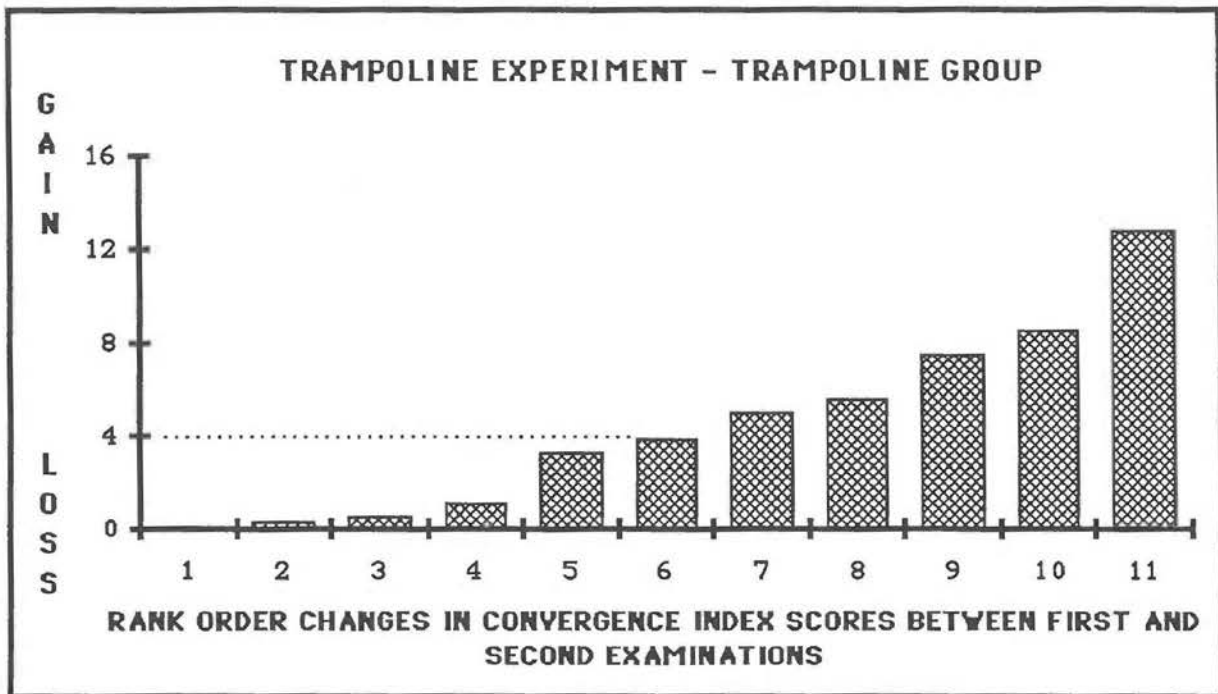


Figure 3. Ordinate axis = Convergence Index Units. Abscissa Axis = Individual Subjects.

Figure 3 shows the Ci Scores for the Trampoline training group. Ten of eleven Trampoline subjects had increased Ci Scores following training, with a mean increase of 5.87 Ci units and a standard deviation of 4.99.



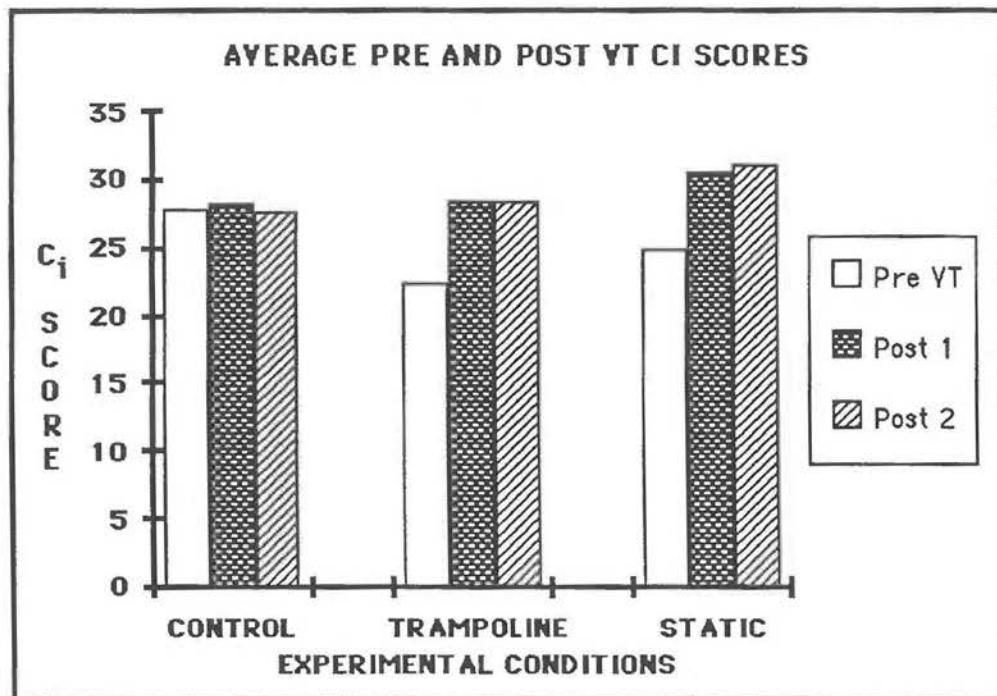


Figure 4.

Figure 4 displays how the three groups retained the effects of training three months following the completion of the training sessions.

1. The vectographic training had a greater effect on the measurements at near than those at distance. While recoveries increased significantly both at far and near, vergence breaks only changed significantly at near. This was the case for both the Static and Trampoline Groups. None of the values for the Control group changed significantly at any distance.

2. The vergence ranges for both experimental groups expanded significantly, and the changes were maintained over a three month period. Refer to Graph 4 for illustration. No change was noted in the range for the control group.

3. For the Trampoline Group, changes were more significant with the convergence ranges than divergence ranges for recoveries at distance, breaks at near, and recoveries at near. Changes in convergence versus divergence were not significant for breaks at distance. For the Static Group, the same pattern of significance was found. Changes were more significant with the convergence ranges than divergence ranges for recoveries at distance, breaks at near, and recoveries at near. Changes in convergence versus divergence were not significant for breaks at distance. The Control group showed no significant changes in convergence versus divergence at any distance.

4. The Trampoline Group recoveries at distance were significantly changed while the breaks at distance did not significantly change. Both the breaks and the recoveries changed significantly at near, with the breaks showing a slightly higher significance than the recoveries. The Static Group showed the same kind of pattern of significance as the Trampoline Group for both distance and near changes. The Static Group recoveries at distance changed significantly, while the breaks did not. Both the breaks and recoveries at near changed significantly following training, with the breaks showing a higher significance than the recoveries. Thus, for both the Trampoline Group and the Static Group, the recoveries were more significantly changed than the breaks at distance, and the breaks were more significantly changed than the recoveries at near. The Control Group showed no significant changes following the training period.

5. The total magnitude of the absolute duction range from extreme convergence to extreme divergence did expand significantly for both experimental groups following training. For the Trampoline Group, breaks and recoveries expanded significantly at far and near. The Static Group showed the same pattern of significance. The Control Group showed no such expansion of the range after the training period.

## Discussion

The stated hypothesis was that the utilization of a mini-trampoline would increase the effectivity of vergence range building. This study, however, showed no statistically significant increase in the training effect by incorporating a mini-trampoline as compared to training without one. Possible explanations for the rejection of the hypothesis are: 1. Jumping on a trampoline does not enhance vergence range training. 2. The incorporation of a trampoline may be regarded as a finishing technique where involving whole body movement is only effective after the patient has developed sufficient vergence ranges. This whole body involvement is considered to be a more "real world" technique, thus embedding the training effect and enhancing transfer to daily life. 3. With increasing physical fatigue, the subject's endurance level and ability to maintain fusion diminishes due to attention to more than one task. 4. The use of the trampoline may increase motivation in unmotivated patients. If all of the subjects in the study were sufficiently motivated, then the trampoline may not be necessary and therefore, would have no added effect. 5. The use of the trampoline may have an immediate effect on vergence range building, but may plateau off allowing for the other group to catch-up. Even though the hypothesis was rejected, the use of a trampoline as an adjunct to range building in clinical practice may be justified for factors not evaluated in this study.

The utilization of vectographic training at two meters increased vergence ranges both at near (40cm) and at far (6m) as measured phorometrically. Even though the total training time was

brief (a total of three hours), a significant change in ranges did occur. Therefore, this form of training is successful in building ranges, thus increasing the ZSBV. The effectiveness of training was further demonstrated by the amount of retention shown by the post training findings taken three months later.

Based on clinical observation, we expected to see a greater effect on the convergence ranges than the divergence ranges. This concept was shown to be statistically valid in this study. We expected to see a greater effect on vergence breaks than recoveries, because vergence breaks are more quickly modified than vergence recoveries. We expected this because the subjects received only three hours of training. We also expected more variability in repeated vergence measurements before training as compared to after training. This was based on the assumption that the subjects would learn to respond with greater accuracy after training, and that subjects would be more sensitive to the fatigue factor prior to training.

Our subject base was limited to college student aged 20 to 35 years of age. Further research should explore effects on different age populations. Individual training versus group training (as in this study) may yield different findings than those reported here. However, utilizing our group training research approach, we found the training technique described here produced a statistically significant increase in vergence ranges, and this change persisted three months following conclusion of the training. No further enhancement of ranges could be elicited by the incorporation of a trampoline into the training regimen.

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## **APPENDIX A**

### **Normative Analysis**

Normative Analysis was utilized in this project to discern if potential changes in vergence ranges were significant or due to chance variations.

Normative Analysis is a form of case analysis developed by Haynes. It is commonly used for evaluating a subject's individual and cumulative analytical test scores in order to develop a diagnosis and/or a treatment. It can also be used to determine the potential effectivity of treatment, through a statistical comparison of before and after intervention findings.

With Normative Analysis accommodative and/or convergence findings are converted into a common metric, whereby each finding in the analytical examination is converted to a standard score. This allows direct comparison between disparate or unrelated clinical tests and classifies each finding as normal, above or below expected. The individual standard scores are summed to yield a cumulative index score. An index score is developed for accommodative findings, and/or the vergence findings enabling the evaluation of either the convergence system as a whole (as compared to the individual findings), or the accommodative system as a whole. If analytical findings need to be compared before and after intervention, Normative Analysis can be utilized to ascertain if a change in the index score is statically significant or a probable function of chance. The index scores can thus be used to determine if changes in motor behavior are a function of clinical interventions (i.e. vision therapy, lens effectivity, etc.), or of chance. A change of greater than or equal to four convergence index points constitutes a significant gain at a 5% level of confidence.

For further information regarding the Macintosh computer program version 1.3f of Normative Analysis please contact Dr. Harold M. Haynes, Distinguished Professor of Optometry at Pacific University College of Optometry, 2043 College Way, Forest Grove, Or 97116.