Normalization of Disparity Vergence in a Clinical Population Using a Random Dot Stereo Butterfly

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Abstract

The purpose of the study is to compare the use of various techniques in the measurement of disparity vergence at near and establish clinical norms using a clinical population. Our project will compare standard Risley vergence measures to hand held bar vergence with reduced Snellen targets, to prism bar break and recovery values using the Random Dot Stereo Butterfly.

Introduction

"All human eye movements have one of two functions: to support the high resolution of foveal vision or to prevent neural blurring of images due to retinal image motion." Of the six types of eye movements, vergence movements are most prone to functional anomalies (1). Therefore, it is important to be able to measure vergences on all patients, using various techniques that are appropriate for each patients testing ability.

The most common binocular anomalies are convergence insufficiency (CI) and convergence excess (CE). It has been noted that approximately 30% of patients less than 30 years of age suffer from convergence insufficiency (2). Symptoms of both CI and CE are inability to read for long periods of time without asthenopia, diplopia, frontal headaches, tired eyes and even short attention span while reading (1). Vergence measurements are important for diagnosing, treating, and monitoring binocular problems. Patients may develop binocular problems due to school and/or family stress, to being pushed hard at work, or from computer use.

Students and adults working on computers can develop Computer Vision Syndromes. Surveys of optometrists show that approximately one out of six primary-care eye examinations is given in the United States primarily due to vision and eye-related problems at computers (3). Computer use involves converging the eyes for a typical near distance of the computer. Patients that suffer from CI and CE may develop symptoms while using the computer. Older adults may suffer from convergence insufficiency since they use more plus for computer distance, making them more exophoric. There is evidence that symptoms of discomfort are related more to vergence problems than to accommodative problems (3).

While monitoring and treating these problems, it is useful to measure and observe the patient's vergences to help assess the effects of treatment. Considering this, it is important for optometrists to have a variety of methods of measuring vergence movement. This ensures that more challenging patients, like children or special needs populations can be properly tested.

Two commonly used methods to measure vergence ranges in clinical practice are Risley prisms behind a phoropter (4) and bar prism using reduced Snellen targets (5,9,10). Our study re-evaluated normative values for these two methods and compared them to results of vergence measurement using a bar prism with a Random Dot Stereo (RDS) target.

Using the RDS Butterfly as a target is a proven way to hold the attention of children and special needs patients. The patient is simply asked to report when the butterfly disappears as the doctor continually adds more prisms. This is measuring the break point. The doctor then reduces the amount of prism until the butterfly can then be re-visualized, measuring the recovery value. The goal of the current study was to validate normative values for the RDS.

The RDS method has advantages over the more commonly used techniques. Schieman lists four major reasons why the RDS is better than using a phoropter (4);

1. It is easier to test children without the restriction of the phoropter
2. It allows direct observation of the eyes
3. The presence of peripheral cues during testing provides conditions more closely approximate to normal seeing conditions
4. The prism bar provides asymmetrical vergence, which more resembles natural conditions.

In testing children, the phoropter has also been noted to decrease attention and does not allow in many cases for proper positioning (6). Another drawback when using both the Risley prism method and/or the Snellen/bar method is the use of vertical Snellen letters. Vertical Snellen letters do not provide a suppression control. According to Wesson (5,9,10), lack of suppression control can lead to an over estimation of vergence ranges because diplopia will not be reported until the stimulus is outside the suppression zone. The RDS method does however provide a solid suppression control. A suppression check ensures that a true binocular response is being evaluated (4). Wesson noted that using a bar prism over a rotary prism also has advantages, such as providing a more natural visual environment and that the test itself allows convergence or divergence in discrete steps rather than a smooth pursuit movement (5,9,10). Burian has exhibited that large peripheral stimuli, such as the RDS, tend to be stronger vergence stimuli than smaller stimuli as related to the increased Panum's fusional area utilized in the target (7).

The primary disadvantage of using the RDS target prior to this study was the lack of well-established normative values. Another perceived disadvantage is the lack of a blur point value. However, Schieman found that blur points are difficult to find, especially in children (4). It has also been noted by Sheard that for a patient with a heterophoria, the break value is used to determine if and how much prism is to be prescribed (6). Also discussed by some, is that the Base Out (BO) to break point is most diagnostic with exophoric patients, while the Base In (BI) recovery is often the most diagnostic with esophores, especially in younger/special needs populations (1,11,12). Therefore, not having a blur point for the RDS technique is not always critical because it is not frequently used to predict symptoms or to prescribe prism.

A similar study by Wrubel, et., al. (2), using students, faculty and staff at the Michigan College of Optometry (MCO), compared the same three techniques. Their paper confirmed that the RDS Butterfly bar method was indeed valid when compared to Risley phoropter vergences or Wesson bar vergences. They found that bar vergences with the RDS Butterfly were closer in value to the Risley's ("ramp") than the Wesson's ("jump"). Wrubel's study used subjects that were very familiar with the tests, whereas this paper used a clinical population.

Methods

Subjects

The study population contained 60 subjects between the ages of 5 and 35. They were patients presenting for eye examinations at the Michigan College of Optometry Senior internship sites. The subjects were asked to sign a consent form and were informed of the nature and purpose of the study before participating (see appendix A). Any questions about the procedure were answered prior to collecting any data.

Subject Screening

All 60 subjects were screened in the process of their eye examination to determine eligibility for the study. Monocular acuities were taken and the patient's ability to appreciate the Random Dot Stereo (RDS) Butterfly was checked. Only patients between the ages of 5 and 35 that had monocular acuities of 20/30 or better at near, could appreciate the RDS Butterfly, and had consented to be a part of the study were included. No other aspects of the patient's binocular system were evaluated for the purpose of the study. Patients with binocular problems were not eliminated or put into a separate category. This was done to mimic the wide variety of patients that are encountered in typical optometric practice. Patients with overt ocular or systemic disease that could impact on their performance were eliminated from the study.

Procedure

Three measurements of disparity vergence ranges were performed with a thirty-second-rest period between each test. All Base In (BI) measurements were performed before Base Out (BO) and prism bars were placed in front of the right eye of the subject. The order of the three tests for vergence ranges was administered randomly to control for sequence effects, with the use of a randomized number chart generated via computer.

Measurement A-- (Risley phoropter vergence)

This vergence range measurement was performed with a vertical line of 20/30 reduced Snellen equivalents at 40 cm. The subjects were instructed to keep the target clear and inform the examiner when the letters blurred and then when they broke into two images. Once the image broke into two, the subject was given 3 seconds to attempt to refuse the image. Prism was introduced in equal amounts in front of both eyes by Risley prisms in a phoropter at the rate of 3-5 prism diopters per second.

After a break point was established, the subject was instructed to inform the examiner when the image had fused back into one image. The prism was moved again at a rate of 3-5 prism diopters per second.

Measurement B-- (Wesson Bar vergence)

This measurement of vergence range was performed with a vertical line of 20/30 reduced Snellen equivalents at 40 cm. A Beren's bar prism with 1-20 prism diopters in 2 diopter steps, and 25-40 prism diopters in 5 diopter steps was used. The subjects were instructed to keep the target clear and to inform the examiner when the letters blur and when they broke into two images. Once the image broke into two, the subject was given 3 seconds to attempt to refuse the image. The bar prism was moved by one step per 3 seconds until blur and break were reported. The subject was then instructed to inform the examiner when the images fused back into one. The prism was reduced by one step per 3 seconds.

Measurement C-- (RDS Butterfly & Bar vergence)

This measurement of vergence range was performed with the RDS Butterfly held at 40 cm. The Beren's prism was also used in this measurement. The subjects were instructed to inform the examiner when the butterfly disappeared. Once the butterfly disappeared, the patient was given 3 seconds to attempt to make the image reappear. Prism was inserted one step per 3 seconds until the subject reported disappearance of the butterfly. The subject was then instructed to report when the butterfly reappeared. The prism was introduced at one step per 3 seconds until the patient reported reappearance of the butterfly.

Results

Means and standard deviations of the measurements compared to published normative values can be found in Tables 1, 2, and 3. Two tailed T-tests were performed to compare the findings to the normative values, these values can be found in Figure 6. The base in findings for measurement A (Risley's) were not significantly different than the norm. However, the base out measurements were found to be significantly higher than the norms. For measurement B (Bar/Snellen), the opposite was found. The base in measurements were significantly higher, and the base out measurements were not significantly different. When comparing measurement B to measurement C, no significant difference was found in base in or base out.

Discussion

Vergence testing is essential for diagnosis and treatment of binocular vision anomalies. Therefore, strong normative values for various testing methods are needed. Our study focused mainly on developing normative values and validating the RDS method. It is a relatively simple procedure to perform, requires standard optometric equipment, and has advantages over using the phoropter. The RDS method is a solid way to measure vergences on children and special needs patients. They usually find the butterfly fascinating and will hold their gaze on it longer compared to other targets used for vergence measurement, such as Snellen charts. Measuring vergences in this manner also allows the doctor to observe the patients' eyes more directly compared to Risley measurement. Not only will this method work well for children and special needs patients, but also it will give the doctor an additional, simple test to measure vergences on all patients. Many eye care practitioners already have RDS targets readily available for testing.

Testing NRA and PRA are also common ways of accessing a patient's binocular system. There are however disadvantages of using this method. First, this method puts the patient behind the phoropter, which has all of the negative aspects already mentioned. In addition, a Snellen target is used, just as with Risley and Wesson methods. NRA and PRA are also measuring vergence in different way. With NRA/PRA the actual vergence demand is held constant while accommodation is forced to change. In disparity vergence testing, both accommodation and vergence can change. The stimulus to move the eyes with NRA/PRA is blurring induced by lenses. In vergence testing, retinal disparity causes eye movement, which better simulates natural viewing conditions.

Wesson determined that the "average break value" of Risley prism tests was statistically greater that the prism bar value" (5,9,10). This inconsistency is attributed to the difference between pursuit vergence measurements (Risley measurement) and step vergence measurements (bar prism measurements). In comparing measurement A to measurement B, higher values were found with A in both base in and base out, just as predicted by Wesson.

One of the major differences in the previous MCO study was significantly larger base out findings than previous studies with measurements B and C. These findings were could be attributed to the subjects' familiarity with the test, as well as a large number of esophoric subjects. In this study, the base out findings were not found to be higher in B and C.

Feldman noted that vergence range measurements seem to depend on the size of the stimulus, the amount of detail and the type of stimulus used (Flat vs. Stereo). In his study, vergence measurements involving a stereo target were generally lower than that of a flat target. Schieman also reported similar findings. He stated that, "It is logical to assume that when suppression is monitored, average vergence values will be lower because this test is terminated when suppression is detected" instead of when the stimulus advances out of the suppression zone, such is the case when suppression is not monitored with flat targets (4,11). The results of the previous study did illustrate this idea more than the current study. Our calculations showed that the two modes of measurement gave nearly identical results, however when considering standard deviation, one could still hold Feldman's statement correct.

The inconsistencies found in the base in and base out between measurements A and B could be the result of not eliminating patients with "subnormal" binocular systems. It may also be due to a lack of patient understanding with the three tests, along with individual cooperation. Many of the subjects were from a correctional facility, were children or had never been exposed to the types of tests that were used. In addition, Sheedy and Saladin noted that different sub-populations could dramatically affect the results of vergence measurement (8). In comparing measurement B and C with t- test calculations, it was found that a statistical relationship exists. More studies should be done to confirm this relationship, and establish solid normative values.

Conclusions

The results of this study indicate that the RDS method is indeed a valid procedure for testing vergence ranges. The means of the RDS method were significantly similar to the findings for prism bar measurement with reduced Snellen targets. This study did however reveal some inconsistencies that may be explained by the population tested, not knowing how many esophoric and exophoric patients were measured, and not knowing if patients had binocular dysfunction and/or accommodative problems. We know that vergence measurement with a RDS target is valid and similar, if not a little lower, than Snellen/Bar measurement. However clinicians should use the same testing method consistently, such as the RDS method. This will allow more consistent monitoring of a patient's progress following optical correction and/or after vision therapy. One could also use the RDS method when taking measurements on non-problematic/standard optometric patients, as long as they are aware that the normative can be slightly lower than values obtained with a Snellen target.

Table 1. Risley Vergence Results Measured with Reduced Snellen Target (Measurement A)

	Mean of Clinical Study	Standard Deviation	Mean of Bangert – Smith Study (MCO)	Standard Deviation (MCO)	Published Mean (Morgan)
BI Blur	13	4	13	4	13
Break	21	5	18	5	21
Recovery	13	6	13	6	13
BO Blur	20	8	19	7	17
Break	23	9	25	9	22
Recovery	13	9	16	10	12

Table 2. Bar Vergence Results Measured with Reduced Snellen Target (Measurement B)

	Mean of Clinical Study	Standard Deviation	Mean of Bangert – Smith Study (MCO)	Standard Deviation (MCO)	Published Mean
BI Blur	11	4	12	3	
Break	17	5	16	5	13
Recovery	12	4	12	6	10
BO Blur	15	6	18	6	
Break	19	9	31	10	19
Recovery	14	7	26	10	14

Table 3. Bar Vergence Results Measured with RDS Butterfly Target (Measurement C)

	Mean of Clinical Study	Standard Deviation	Mean of Bangert – Smith (MCO)	Standard Deviation (MCO)
BI Break	18	6	16	5
Recovery	13	5	12	4
BO Break	20	9	26	10
Recovery	14	8	21	9

Figure 1: Comparison of Base In Findings

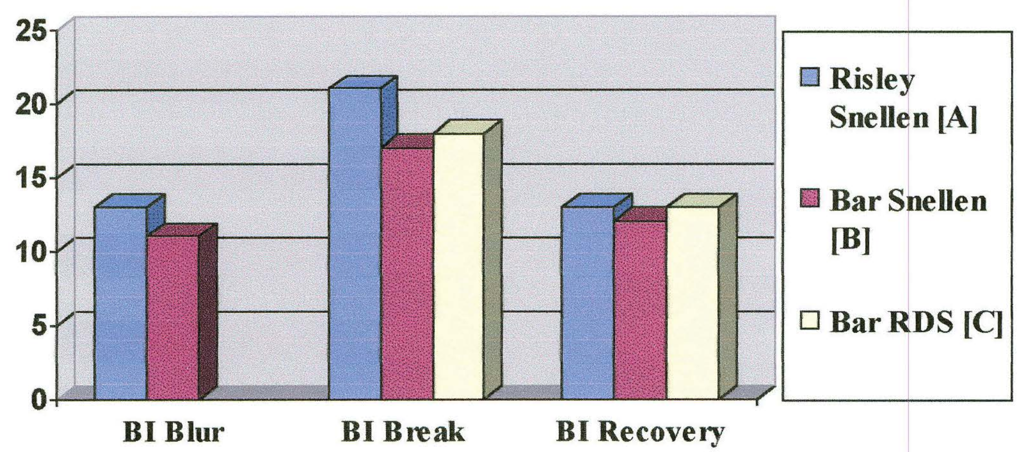

Figure 2: Comparison of Base Out Findings

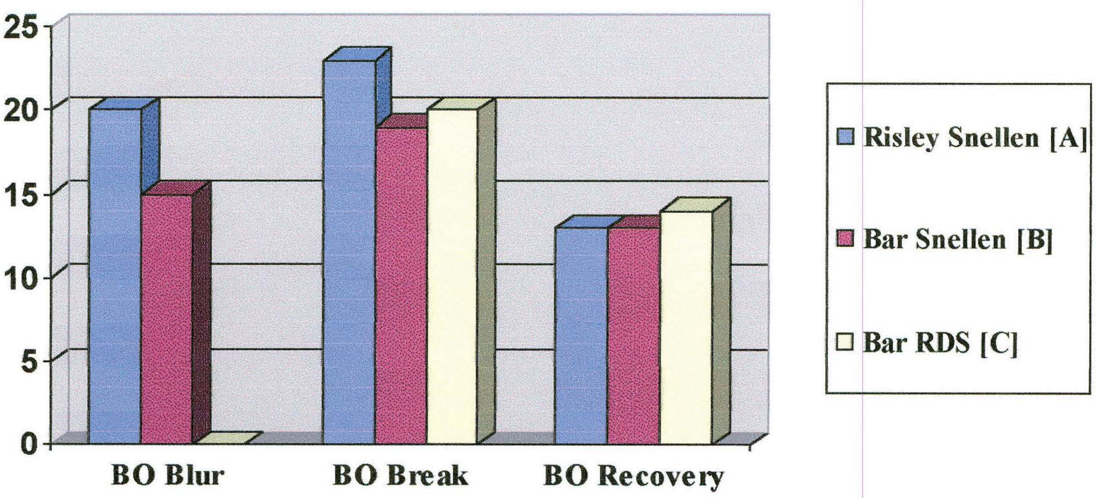

Figure 3: Comparison of Measurement A to Published Means

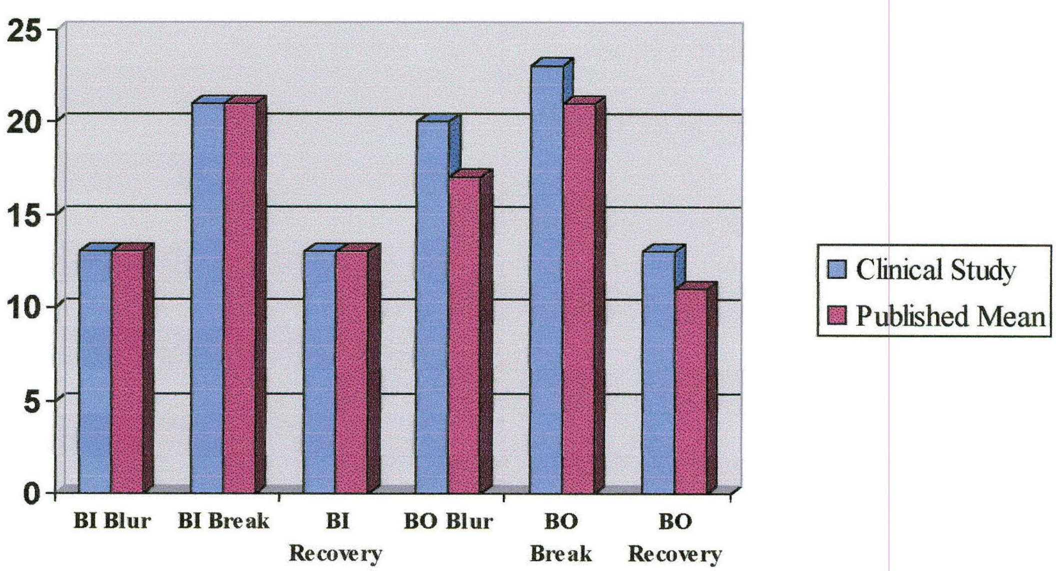

Figure 4: Comparison of Measurement B to Published Means

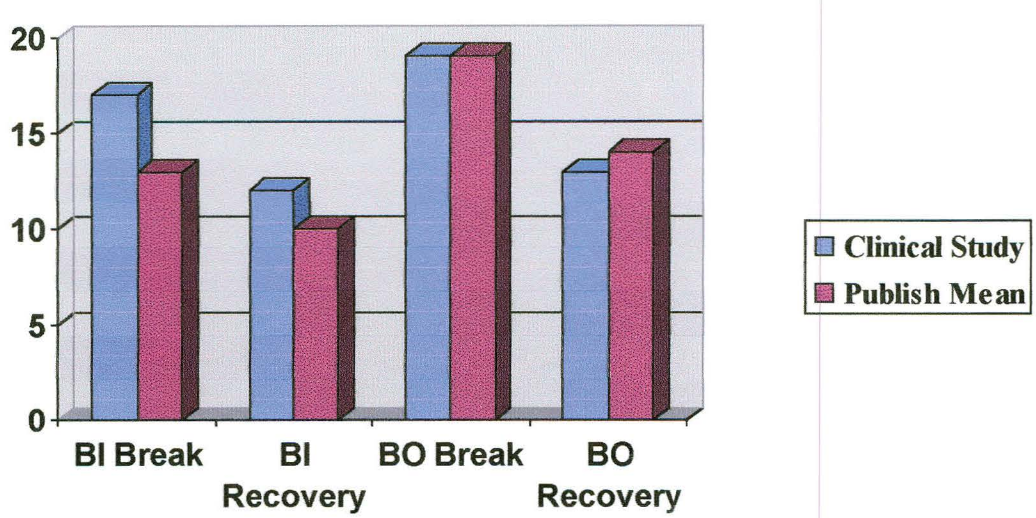

Figure 5: Comparison of Measurement C to Previous MCO Study

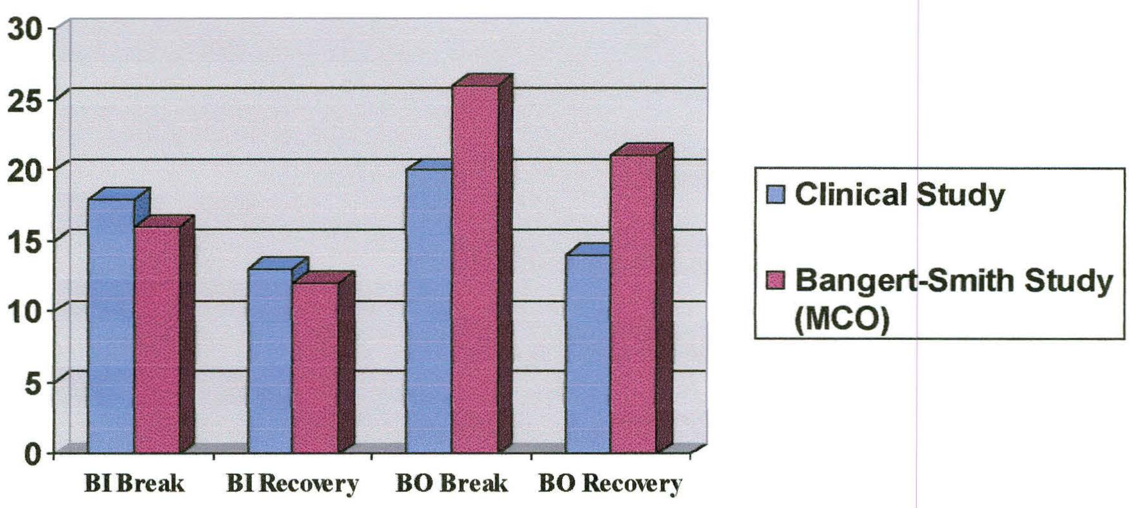

Figure 6: T-Test Results using P=0.05

Test Used	Compared To	T Test Value
BI Bar Break	BI RDS Break	0.997
BO Bar Break	BO RDS Break	0.480
BI Bar Recovery	BI RDS Recovery	0.235
BO Bar Recovery	BO RDS Recovery	0.571

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- Procedures followed for testing in this study were in accordance with the ethical standards of the Human Subjects Review Committee at Ferris State University and with the Helsinki Declaration of 1975, as revised in 1983.