Normalization of Disparity Vergence Ranges using a Random Dot Stereo Butterfly Target

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Abstract

The purpose of this study was to compare the use of various techniques in the measurement of disparity vergence at near and establish clinical norms acceptable with previously documented ones. This paper compared the 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 target.

Introduction

Symptoms of asthenopia are often times the result of binocular oculomotor deficiencies (1). The measurement of vergence ranges, the range over which disparity vergence is free to change while accommodation is held constant, is one pertinent component within a binocular oculomotor assessment. A common technique of vergence measure is the use of a vertical line of reduced Snellen letters and a phoropter with Risley prisms, or with hand-held bar prisms (2). Both of these techniques have drawbacks, however. The use of the phoropter can often be difficult with children or special needs patients, and the commonly used reduced Snellen target does not have the ability to monitor for suppression. Schieman (3) has suggested four reasons why it may be advantageous to assess disparity vergence in an environment other than traditional testing with a phoropter:

1) Easier to test children without the restriction of the phoropter
2) Allows direct observation of the patient's eyes
3) The presence of peripheral cues during testing provides conditions more closely approximate to normal seeing conditions
4) The prism bar test requires asymmetrical vergence and step vergence type changes, which may more closely resemble natural conditions.

Another drawback to the use of the above mentioned traditional testing technique is that use of the vertical line of Snellen letters does not provide a suppression control. According to Wesson (4), this may cause an over estimation of the vergence range because diplopia will not be reported until the stimulus is outside the suppression zone.

He also stated that the materials for such testing should be easily obtainable and maintain the attention of children (5). Burian has shown that large peripheral stimuli tend to be stronger vergence stimuli than smaller stimuli as related to the increased Panum's fusional area utilized in these targets (6).

The purpose of this study was to establish clinical norms for the measurement of disparity vergence ranges at near using a bar prism and the Random Dot Stereo (RDS) Butterfly as the target. The combination of the bar prism measurements with the advantages stated above and the large, binocular target of the RDS Butterfly should help to minimize some of the difficulties encountered when attempting to measure disparity vergence ranges. This technique also has the advantage of ease of administration using equipment already acquired by most practitioners. The RDS Butterfly is a novel stimulus that easily holds the attention of children and special needs patients and requires only simple instruction. The patient is instructed to report when the butterfly disappears (the break point) while the prism amount is increased and then report when it reappears (the recovery point) while the prism amount is decreased. One drawback to this type of administration is the absence of a blur point. However, in several studies, including one performed by Scheiman, have reported difficulty in obtaining the blur response, especially when the patients are children (3). In addition, several researchers have discussed that frequently (especially in children) the most useful measurement from disparity vergence ranges is the break point for exophores and the recovery point for esophores (1, 10, 11).

Methods

Subjects

Eighty-one subjects participated in this study. Subjects were students, faculty, or staff at Michigan College of Optometry. There were 58 females and 23 males between the ages of 18 to 41. All subjects were asked to sign a consent form and were informed on the nature of the study prior to participation. Appropriate refractive correction was worn by all subjects throughout the testing. All subjects were systemically healthy and free of any significant ocular health anomalies. Two subjects were eliminated from the study because of their inability to appreciate the RDS Butterfly under normal viewing conditions.

Procedure

All subjects first participated in several screening tests to determine their status in either a *normal* or *subnormal* subgroup. Screening tests *(Figure 1)* included distant and near visual acuities, far and near cover test, accommodative amplitude by the push up method, near point of convergence, accommodative facility at near with +/-2.00 flippers, vergence facility at near, and VonGraephe phorias horizontal and vertical (all procedures performed according to Clinical Procedures for Ocular Examination by Carlson, et al (7). All subjects were given a standard set of instructions. Any participant who was found to have more than one of the above outside of Morgan's Normative Values (2) were placed in the subnormal subgroup. This resulted in a *normal group of 39* subjects and a *subnormal group of 40* subjects. Two different examiners tested each subject; one performed the screening tests and one performed the three-vergence measurements. Normal versus subnormal group status *was not known* by the examiner performing the vergence measurements.

Three measurements of disparity vergence ranges were performed with a 30 sec rest period between each test. All base in (BI) measurements were performed before base out (BO) and prism bars were placed before the right eye of subjects, as previous studies showed no significant difference between order of presentation (BI verses BO) or presentation of bar prism before the dominant or non dominate eye (5, 8). The order of the three-vergence range measurements was administered randomly (random number generator) to control for sequence effects.

Measurement A

These vergence range measurements were performed with the vertical line of 20/30 reduced Snellen equivalent targets at 40cm. The subjects were instructed to keep the target clear and to inform the examiner when the letters blurred and then when they broke into two images. Prism was then introduced in equal amounts before 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 fused back into one image while the prism was removed at 3-5 prism diopter per second.

Measurement B

This measurement of vergence range was performed using the same vertical line of 20/30 reduced Snellen letters at 40cm, but was measured using a Beren's bar prism with 1,2,4-20 prism diopters in 2 diopter steps, 25-40 prism diopters in 5 diopter steps (Figures 2 & 3)

Again the subjects were instructed to keep the target clear and to inform the examiner when the letters blurred and then when they broke into two images. The bar prism was then moved by one step per second until blur and break were reported. The subject was then instructed to inform the examiner when the images fused back into one and the prism was reduced by one step per second until recovery was recorded.

Measurement C

This measurement of vergence range was performed using the Random Dot Stereo Butterfly as the target held at 40cm. The Beren's prism was also used in this measurement. The subjects were instructed to inform the examiner when the butterfly disappeared (the break point). Prism was then inserted by one step per second until the break point was reported. The subject was then instructed to report when the butterfly reappeared (the recovery point) and prism was reduced at one step per second until the recovery point was reported.

Results

Tables 1,2, and 3 list the mean and standard deviation values for the three measurements performed (rounded to the nearest whole number) and compare these to the means published by Wesson in an earlier study (5).

A two-tailed t-test determined that there was no significant difference between male and female subjects, or the order that the three-vergence measures were performed.

When comparing the normal group (subjects who had one or less screening test finding outside of Morgan's normative values) and the subnormal group (subjects who had more than one screening test finding outside of Morgan's normative values), a two tailed t-test indicated that there was no significant differences between the vergences measurements A and B performed on these sets of subjects. However, the subnormal group was found to have significantly lower BI to break and BI to recovery values with vergence measurement C (using the RDS Butterfly target) than the normal group. The most commonly missed screening tests in the subnormal group were distant and near phorias. Sixty-six percent of the subjects who were outside of Morgan's norms for near phorias had an esophoric posture.

There was no significant difference in measurement A (the Risley vergence values) measured in this study and those found in Borish (2). Vergence measurement B (Bar vergences with a reduced Snellen target) were significantly greater or higher than those published by Wesson (5). In contrast, vergence measurement C (using the RDS Butterfly target) was significantly less than vergence measurement B, but was still significantly greater than those published by Wesson (5).

Discussion

In an effort to develop a procedure to more efficiently, and more confidently measure vergence ranges in children and special needs populations, the use of a random dot stereo target measured with bar prisms has been frequently used by clinicians, but does not have fully established normative values. This study attempted to establish or strengthen these normative values.

Wesson found that the "average break value of Risley prism tests were statistically greater than the prism bar values" and attributed this to the difference between pursuit vergence (as in Risley measurements) and step vergence measurements (as in bar prism measurements) (8). In our study, this was indeed true for the BI break and recovery values, but for BO measurements, the prism bar values of measurements B and C were greater. In Wesson's study, subjects were from a clinical population. However, the current study was performed predominantly with optometry students who were familiar with the procedures being performed. Feldman, when comparing the repeatability of vergence measurements using different targets, found that the retest measurements with a RDS target were 5-10 prism diopters greater than the original measurements. He hypothesized that this was because the RDS test requires more experience and familiarization than other tests (9). The previous experience of the current subjects with the RDS butterfly testing target may account for the larger BO readings with these measurements. Schieman, using a children (6-12 years old) subject population and performing bar prism vergence measurements with a suppression check, also found that Morgan's normative values (established using Risley prisms) were higher for BI to break and recovery, but their findings for BO to break and recovery were significantly higher than Morgan's normative values (BO break 23 (+/-8), and BO recovery 16 (+/-6)) (3). In addition, Sheedy and Saladin when comparing expected values for vergence ranges found by Morgan, the optometric extension program, and their own study found that different sub-populations could dramatically affect the values (Table 4). Morgan's data represents a pre-presbyopic clinical population, while Sheedy and Saladin used a non-clinical, young adult (ages 20-30) population. A significant difference was noted in the positive vergence ranges (BO), and Sheedy and Saladin concluded that "ignoring any age differences, it would seem that a clinical population has smaller positive vergence ranges than does a nonclinical population" (10)

Feldman also found that vergence range measurements seem to be dependent upon the size of the stimulus, the amount of detail and the type of stimulus (flat vs. stereo). In his study, vergence measurements that involved a stereo target were generally slightly lower than a flat target. This is also what was found in the current study. Vergence measurement B values, which involved a flat target, were significantly larger than measurement C, which used a random dot stereo target (9). Schieman also supported this finding when monitoring suppression during vergence measurements. He stated that it is "logical to assume that when suppression is monitored, average vergence values will be lower because the test is terminated when suppression is detected" instead of when the stimulus proceeds outside the suppression zone, as is the case when suppression is not monitored (3).

Conclusions

The results of this study indicate that the measurement of vergence ranges at near using a Random Dot Stereo Butterfly target and a bar prism is indeed a valid clinical procedure. This method needs to be further analyzed using a more clinical population, children, or special needs patients to ensure that the above found inconsistencies can indeed be attributed to the biased population used in this study.

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Figure 1

Screening Tests
Distant visual acuity (Snellen target)
Near visual acuity (reduced Snellen target
Distant cover test
Near cover test
Accommodative amplitude (Push up method)
Near point of convergence
Accommodative facility (+/-2.00D flippers)
Vergence facility at near (3BI/ 12BO)
VonGraephe horizontal phoria at distant
VonGraephe vertical phoria at near
VonGraephe horizontal phoria at near

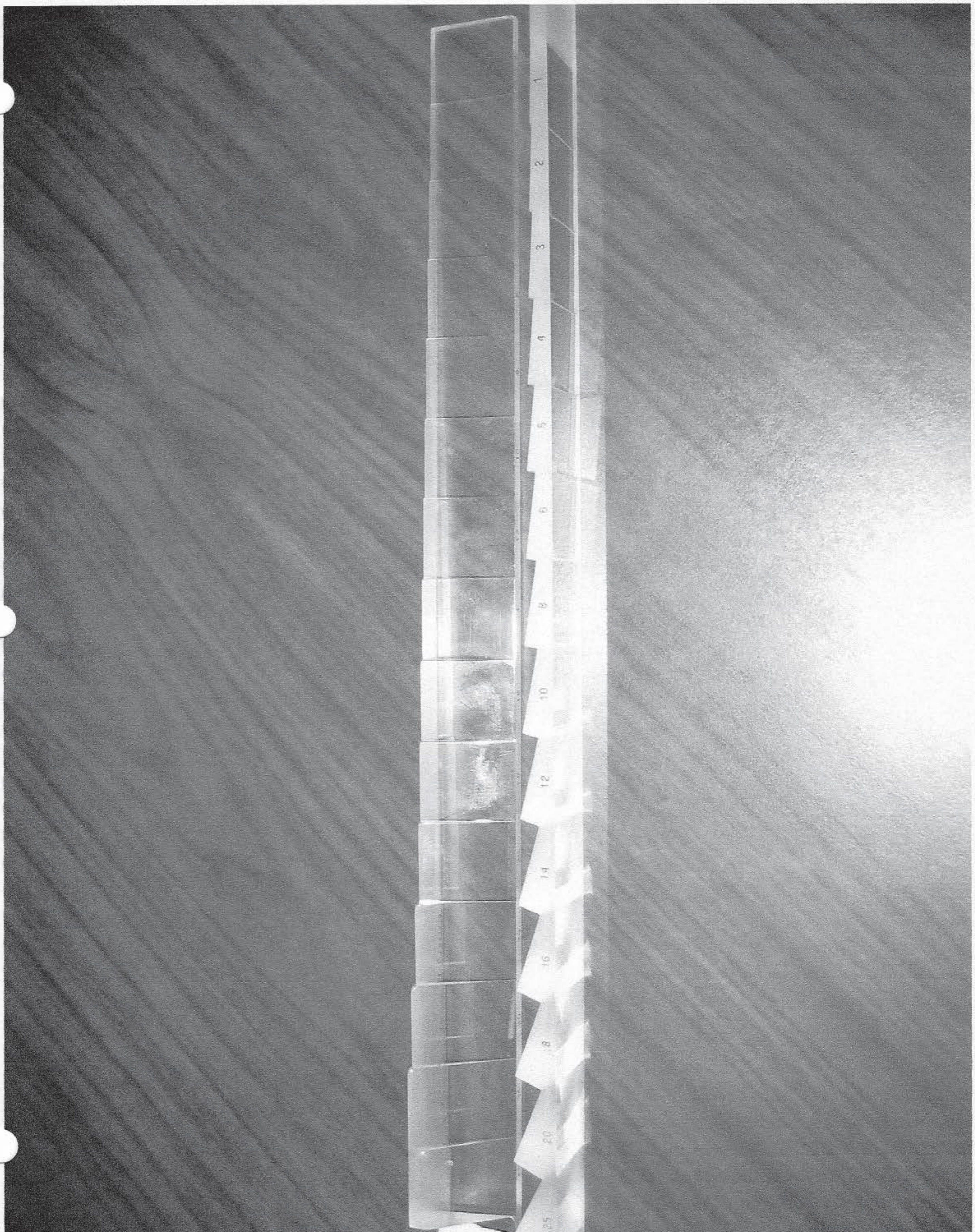
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Table 1

A: Reduced Snellen target measured by Risley prisms in the phoropter			
	Mean	Standard Deviation	Published Mean (2)
BI Blur	13	4	13
Break	18	5	21
Recovery	13	6	13
BO Blur	19	7	17
Break	25	9	22
Recovery	16	10	12

Table 2

B: Reduced Snellen target measured by bar prisms			
	Mean	Standard Deviation	Published Mean (5)
BI Blur	12	3	
Break	16	5	13
Recovery	12	6	10
BO Blur	18	6	
Break	31	10	19
Recovery	26	10	14

Table 3

C: RDS Butterfly target measured by bar prisms		
	Mean	Standard Deviation
BI Break	16	5
Recovery	12	4
BO Break	26	10
Recovery	21	9