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Variability Of The Synoptophore For Measuring Fusional Vergence In Intermittent Exotropia

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ABSTRACT

Background: To determine the variability of the synoptophore in children with IXT. The study demonstrates that the synoptophore effectively measures the near-positive fusional vergence (PFV) breakpoint, although variability exists in distance PFV breakpoint measurements. **Aim:** The study aims to evaluate the repeatability of synoptophore measurements, focusing on blur, break, and recovery points of positive and negative fusional vergence (PFV and NFV) at near and distance fixation in children diagnosed with intermittent exotropia (IXT). **Material and Methods:** Ninety-eight IXT subjects, aged 6 to 16, were examined. Measurements of near and distance PFV and NFV blur, break, and recovery points were conducted with a synoptophore across two visits, spaced 24 hours apart, involving the same examiner, environment, and testing conditions. The intra-class correlation coefficient (ICC), smallest detectable change (SDC), and coefficient of repeatability (CR) were calculated for these measures. **Result:** The PFV break point ICC has excellent near reliability (0.90) and moderate distant reliability (0.67). SDC (14.1), CR (19), and ICC (0.90) demonstrated a consistent synoptophore near PFV breakpoint. The ICC PFV recovery points demonstrated reliable performance at both distances, with moderate reliability (0.69) at near distances and good reliability (0.80) at distance for NFV breakpoints. Between visits, the near NFV recovery point was consistent with ICC (0.83), SDC (13.8), and CR (±16), showing good reliability. **Conclusion:** The study found that the synoptophore provides consistent and reliable assessments of the near PFV breakpoint; however, other near and distant FV parameter measurements show low repeatability.

Keywords: *Fusional vergence, intermittent exotropia, negative fusional vergence, positive fusional vergence, Synoptophore*

1. INTRODUCTION

Intermittent exotropia (IXT) is the most common form of strabismus seen in pediatric populations, accounting for 50–90% of all cases. [1, 2, 3] The incidence of IXT in children is 3.3%. [4] Fusion vergence (positive and negative fusional vergence) arises from sensory and motor responses, reflecting the eye's capacity to converge or diverge to sustain binocular single vision. This phenomenon occurs when images of the attended subject shift away from one fovea, leading to disparity. [5] The synoptophore is frequently found in the orthoptic clinic. The synoptophore is a reliable tool for assessing and managing binocular vision disorders. [6]

Positive fusional vergence (PFV) and negative fusional vergence (NFV) can be quantitatively assessed in clinical settings using a synoptophore or rotary prism. [7] In contrast, the step vergence method is employed with a prism bar. Variability is recognised as a characteristic of the IXT. Control levels, stereopsis, and deviation angles exhibit diurnal variability

Variability in synoptophore measurements impacts treatment outcomes, guides vision therapy and surgical decisions, and monitors disease progression in children with IXT. A previous study evaluated the fusional vergence (FV) in children with IXT using the synoptophore; however, it did not assess the repeatability of the synoptophore measurements. [8] In another study, the authors examined the FV in patients with exotropia and those with orthophoria; however, the repeatability of the synoptophore measurements was not evaluated. [9, 10]

The study aims to evaluate differences in the intra-class correlation coefficient (ICC), coefficient of repeatability (CR), and small detectable change (SDC) for measuring FV in children with IXT using the synoptophore.

2. Materials and Methods:

The Biomedical Research Ethics Committee reviewed and approved the study at the Regional Institute of Ophthalmology (RIO). The research adhered to the principles outlined in the Declaration of Helsinki. The investigation included 98 IXT subjects, aged between 6 and 16 years, who visited the RIO from November 2023 to October 2024. Consent was obtained before enrolling subjects. Table 1 presents the criteria for inclusion and exclusion.

Table 1: Inclusion and exclusion criteria

Inclusion criteria
1. 6 to 16 years old, both genders 2. Office control score for near (0-2) 3. Office control score for distance (0 and 1) 4. Best corrected visual acuity of 6/6 in each eye
Exclusion criteria
1. Convergence insufficiency type exotropia (near deviation ≥ 10PD than distance deviation) 2. Any history of ocular surgery and non-surgical treatment 3. Nystagmus, amblyopia, Restrictive strabismus, and anisometropia 4. Prior botulinum injection and refractive surgery

The exclusion is because amblyopia is often associated with poor stereoacuity and reduced binocularity. [11] In cases of anisometropia, the brain struggles to merge two images of different sizes into a cohesive picture. [12] Additionally, convergence insufficiency, which results in exotropia, undermines the ability to maintain eye alignment at near distances, thus affecting FV.

Each subject underwent a thorough orthoptic evaluation, which included tests of their best-corrected visual acuity, near point of convergence, ocular motility, and anterior segment. The angle of deviation was measured using the prism bar cover test. Stereoacuity was assessed using the Titmus fly test (near), and distance stereoacuity was measured using the distance Randot test. Near and distant office control scores (OCS) were also evaluated.

During two visits, all subjects underwent measurements of their near and distance PFV and NFV blur, break, and recovery points using a synoptophore. At the second visit, the same examiner repeated the same test in the same illumination room 24 hours later. If neither test demonstrated blur, the blur point was determined as the breakpoint.

2.1 Synoptophore assessment

The synoptophore test was conducted in a semi-dark room. The Clement Clarke synoptophore was utilized. The illumination of the synoptophore was adjusted to level four using the knob. The synoptophore measuring FV involved fusion slides (bears slides), two incomplete but similar images shown in Figure 1. If there was fusion, the patient could see a single, complete image (a big bear with two small bears). The synoptophore scale in prism diopters should mark the blur, break, and recovery points. Spread the synoptophore arms progressively, starting with NFV. The task is simple: let me know when the image becomes blurry or resembles two large bears, but try to keep the entire image clear for as long as possible. The “blur” point was recorded when the image began to blur. The “break” point was noted when the large bear doubled, resulting in the

presence of two small bears. After completing the image, the handle was shifted backward to identify the “recovery” point. After a ten-second interval, the PFV was measured.

Figure 1: Synoptophore Fusion Slides

When measuring PFV, the synoptophore arms rotate inward to record blur, break, and recovery points. A -3.0 diopter spherical lens should be added to the synoptophore eyepieces when measuring near FV. The assessment interval for PFV and NFV is approximately ten seconds, providing sufficient time for fusion restoration to occur.
The IXT control was assessed using OCS. The OCS ranges from zero to five, measuring a distance of five meters and 33 centimeters. Subjects exhibiting constant exotropia received a grade of five. Subjects with over 50% exotropia received a score of four, while those with less than 50% received a score of three. If the examiner did not find exotropia during the 30-second observation, ratings were assigned from zero to two based on how long it took to restore ocular fusion. A recovery of fusion within five seconds was grade two, one to five seconds was grade one, and one second was grade zero. [13]

3. Results:

Ninety-eight IXT children, aged 6 to 16 years, with a mean age of 11.8 ± 3 years, fulfilled the study's inclusion criteria. There were 50 males (51%) and 48 females (49%), with a mean age of 11.8 ± 3 years (range: 6-16 years).

At visit 2, the blur point values decreased slightly near PFV, while the distance point values remained stable; the ICC (near 0.85 for blur and 0.78 for distance) showed good reliability at both distances. The confidence interval was set at 95%. For measuring the PFV blur point, 26 subjects (27%) at near and 20 subjects (21%) at distance did not report experiencing blur. At visit 2, there was a slight increase in the near PFV breakpoint, with no noticeable change in distance. The ICC shows excellent reliability (0.90) at near distances and moderate reliability (0.67) at moderate distances. The SDC was 14.1, and CR ±19 near the PFV break point suggested that it was a consistent, dependable measure of the synoptophore. Near and distance PFV recovery point values remained stable at both visits; the ICC (0.79) at near and (0.81) at distance showed good reliability at both distances. The distance PFV breakpoint showed a higher SDC (17.3) and CR (±21), but a lower ICC (0.67), indicating that it is not very reliable and is more likely to vary with different measurements. (Table 2)

Near the NFV blur point, the decrease was minimal, and the distance increased slightly; the ICC demonstrated good reliability. Twenty subjects (21%) at near and twenty-six subjects (27%) at distance reported no blur when evaluating the NFV blur point. Near the NFV breakpoint, there was a slight reduction between visit one and visit 2, and the distance increased slightly; the ICC exhibited moderate reliability (0.69) at near and good reliability (0.80) at distance. The near NFV recovery point remained consistent across all visits, and the distance increased slightly at the second visit. The ICC (0.83), SDC (13.8), and CR (±16) indicated good reliability for assessing NFV recovery on the synoptophore. The ICC (0.68) distance of the NFV recovery point showed moderate reliability. (Table 2)

Table 2: Fusional vergence measurements at two visits, with average values, intra-class correlation coefficient (ICC), smallest detectable change (SDC), and coefficient of repeatability (CR), all in prism diopters (PD). PFV: Positive fusional vergence; NFV: Negative fusional vergence; SD: standard deviation. Bl. =Blur, Br=Break, RC=Recovery

Variables			Visit 1, PD (Mean ± SD)	Visit 2, PD (After 24 hours) (Mean ± SD)	Average of visits 1st & 2rd (Mean ± SD)	Intra-class correlation coefficient	Smallest detectable change, PD	Coefficient of repeatability, PD
PFV	Near	Blur	18.3 ± 11.4	16.6 ± 11.1	17.5 ± 11.3	0.85	15.3	±17.5
		Break	21.8 ± 12.9	23.8 ± 12.3	22.5 ± 13.5	0.90	14.1	±19
		Recovery	14.5 ± 12.9	14.6 ± 10.9	14.5 ± 11.6	0.79	17.7	±18.2
	Distance	Blur	13.7 ± 9.7	13.8 ± 9	13.8 ± 9.4	0.78	16.5	±18
		Break	17.1 ± 11	17.7 ± 10.6	17.5 ± 10.8	0.67	17.3	±21
		Recovery.	9.4 ± 9.3	9.7 ± 9.3	9.6 ± 9.3	0.81	14.9	±19.5
NFV	Near	Blur	13.4 ± 7.2	12.7 ± 6.4	13.1 ± 6.9	0.76	13.6	±20.5
		Break	16.3 ± 7.7	15.6 ± 6.7	16.1 ± 7.2	0.69	14.5	±20
		Recovery	8.8 ± 7.7	8.3 ± 6.2	8.6 ± 6.9	0.83	13.8	±16
	Distance	Blur	13.6± 6.8	14 ± 7	13.9 ± 6.9	0.76	14.6	±18.5
		Break	16.5 ± 7.6	17.5 ± 8	17.1 ± 7.9	0.80	16.2	±20
		Recovery	9.2 ± 6.3	10.2 ± 7.1	9.7 ± 6.8	0.68	13.5	±19

4. Discussion:

The study found that the near PFV breakpoint and near and distance recovery points have excellent to good reliability. The distance of the NFV breakpoint showed good reliability. The findings indicate that the synoptophore was consistent and remained stable when measuring the PFV near the breakpoint in children with IXT. Multiple prior studies have examined the FV parameters using a prism bar and synoptophore; however, the use of the synoptophore has not yielded any information regarding repeatability. The synoptophore provides controlled, objective testing environments by separating images for each eye, which helps ensure a more accurate reading of responses. Meanwhile, the prism bar is more commonly used in clinical settings because it is simple to operate, portable, and dependable for daily use.

The ICC scores below 0.5 indicate poor reliability, those ranging from 0.5 to 0.75 reflect moderate reliability, scores between 0.75 and 0.9 suggest good reliability, and values exceeding 0.9 denote excellent reliability.[14] The current study's FV, measured by the synoptophore ICC, ranged from 0.67 to 0.90, indicating that this test has moderate to excellent reliability. Except for the SDC near the PFV breakpoint, which exhibited nearly equal and low values indicative of precision and reliability, all values were elevated, indicating low repeatability. All values, except for the low CR of the PFV breakpoint, were near or exceeded the mean value, suggesting low repeatability.

Ma et al. obtained similar results in a study on IXT subjects, using the step vergence method with the prism bar. The ICC varied between 0.64 and 0.87, suggesting moderate to good test reliability. The SDC and CR values exceeded the mean, indicating low repeatability. They found that the CR for the distance NFV break was ±18.0, the recovery point was ±18.0,

the distance PFV break was ±20.5, and the recovery point was ±20.0. The near NFV breakpoint was ±18.5, the recovery point was ±14.0, and the near PFV break and recovery point were ±23. The prism bar proved more consistent for measuring near and distance NFV breaks and recovery compared to PFV. [15]The current study indicates that the synoptophore is consistent in measuring near PFV break points and has good reliability in measuring distance NFV break points.

Antona et al. conducted a study on adults with normal binocular vision using a prism bar and found that the CR was lower than in the present study. [16] The control, stereoacuity, and angle of deviation parameters exhibit significant variability in IXT. [17, 18, 19] The current study showed that the CR is higher than that of a patient with normal binocular vision.

Haque et al. found that the synoptophore measured a higher PFV breakpoint than the prism bar, with no significant difference in the NFV breakpoint. They noted that neither method was interchangeable in the clinic. Alrasheed et al. also found essential differences in the PFV and NFV measurements when comparing the synoptophore and prism bar methods. Specifically, the synoptophore method produced higher PFV measurements than the prism bar method. Both studies were conducted on orthophoric and exophoric young adults, and neither analyzed the repeatability of the synoptophore.

Fu et al. found that PFV was reduced in children with IXT compared to the standard control, as measured by the synoptophore and prism bar. PFV and NFV measurements indicate inadequate fusion recovery. Contrary to the findings obtained from the prism bar, no significant differences were observed in mean NFV between children with IXT and their normal counterparts. There was no mention of the repeatability of the synoptophore in this study. S. Georgievski suggested that the synoptophore neither consistently overestimates esotropia angles nor underestimates exotropia angles compared to the prism and cover test.[20] Lança et al. discovered that children with exophoria exhibit lower convergence break points than those with orthophoria and esophoria. [21] This study's strength lies in its perspective, incorporating subjects who generated a complete picture displayed on the fusion slides of the synoptophore at the test beginning to assess near and distant PFV and NFV.

However, this study has some limitations. First, the participants did not indicate the blur point, which is considered the breakpoint in this research. This oversight may have affected the statistical analysis. Secondly, the researchers did not use a one-hour occlusion patch to assess the angle of deviation.

Clinicians should employ specific strategies to minimize the variability of the distance PFV variable, thereby achieving more consistent and reliable results. These include ensuring the same examiner uses a consistent speed and method when moving the synoptophore arms, allowing short rest breaks between tests to avoid fatigue, and taking two or three measurements.

Conclusion:

Fusional vergence can be assessed using a synoptophore in children with IXT, although its repeatability is uncertain. The study found that the synoptophore provides consistent and reliable assessments of the near PFV breakpoint; however, other near and distant FV parameter measurements show low repeatability. Therefore, clinicians should use caution when interpreting distance parameters and consider taking repeated measurements to improve reliability.

Conflict of interest: None

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