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REVIEW

Convergence insufficiency: Review of clinical diagnostic signs

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Abstract

Convergence insufficiency (CI) is a common binocular vision (BV) disorder characterized by difficulty in maintaining motor fusion at near, which affects approximately 7.5 percent of the population. Diagnostic criteria for the disorder are inconsistent, ranging from one to many clinical signs. Methodology for clinical tests is inconsistent in measurement technique, visual targets, required repetitions, and normative values.

This manuscript demonstrates the inconsistencies amongst published studies, and highlights the importance of consistent clinical diagnostic signs, measurement techniques, visual targets, and cut-off criteria. For each clinical sign, the recommended methodology for the procedure is described. Several studies do not take age into account when diagnosing CI in their cohorts. As such, the review emphasizes changes in diagnostic signs with age.

This manuscript highlights the need for consistent and clear procedures and diagnostic criteria amongst clinicians and provides the basis for future studies in terms of diagnostic testing required for CI of varying age groups.

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Introduction

As patients are spending significant time using smartphones, tablets, and computers, as well as reading, it is important to investigate ocular conditions that are associated with near work.[1] Convergence insufficiency (CI) describes the inability or weakness of the fusional convergence system to maintain single binocular vision (BV) at near.[2] The prevalence, diagnostic criteria, and management of CI are inconsistent in the literature. Inconsistent diagnostic testing procedures and cut-off criteria can cause differing diagnoses in the same patient. As an example, consider the expected normative break value for the near point of convergence. If one study considers the value of 6 cm from the edge of the nose or closer as its normative value,[3] whereas other studies[4,5] consider 10 cm from the edge of the nose or closer as its normative value; then a patient with 8 cm break value would be considered abnormal according to the first study, and within

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normal limits according to the other studies. As a result, varying studies report differing prevalence values, diagnostic signs, and cut-off values. This manuscript highlights the existing discrepancies in criteria used to diagnose CI in the literature as well as the effects of age, which can also explain variations in normative values and reported prevalences. For each clinical test, we present recommended clinical procedures and normative values in an attempt to provide a consistent protocol for future experiments.

Methods

Literature search of prevalence studies

A Pubmed database search for relevant prevalence studies written in English and published as journal articles, between the years 1930 and 2018, was conducted. Individual and combined key words were used, including "convergence insufficiency," "prevalence,", "incidence", "binocular vision anomalies". Studies reporting prevalence of CI in patients with strabismus, late-onset CI, or who have undergone traumatic or acquired brain injuries, were excluded. Pertinent peer-reviewed articles from the primary search made on the basis of content and scope were then reviewed. Hand and manual searches were also performed for articles referenced in bibliographies that were not initially retrieved by the search, as well as in specific areas in which information was lacking. Meeting abstracts were excluded. Of the 260 publications retrieved, 33 were selected. Two of these were not pure prevalence studies, but were included because they stated the prevalence of CI in a cohort of participants. Another study reporting the prevalence of adult-onset CI, included participants aged 22 and above, and was therefore included as well.

Discussion

Prevalence

Prevalence of CI reported in the literature (Table 1) differs among studies due to variations in outcome measures used to define CI, methodologies in obtaining outcome measures, age and gender distributions in samples, race, geographic locations, etc.. However, the relationships between these factors and prevalence of CI have not been investigated in depth[6] though they may account for the wide variation of reported prevalence, ranging from 1.7% to 33%.

Diagnostic criteria

Diagnostic criteria vary among studies, from a single sign, such as a receded near point of convergence (NPC) ,[4,7-10] to several signs.[11-17] To demonstrate how this variability can lead to discrepancies amongst clinicians, clinical outcome measures of three representative patients extracted from the cohort of normal control participants from a previous study examining the prevalence of CI in whiplash associated disorder vs. controls,[18] are tabulated in Table 2. Based on Duane's definition of CI[19] (see Table 1), patient #1 would not be diagnosed with CI due to the break point, and patient #2 would not be diagnosed with CI due to the distance and near phoria. Based on Holland's[20] four diagnostic criteria (see Table 3), all patients in Table 2 would be diagnosed as having CI.

Based on Scheiman and Wick's[21] criteria (see Table 3), the cases in Table #2 only fulfill some of these required criteria and are missing several diagnostic outcome measures such as fixation disparity. Additionally, patients #1 and #2 do not have an NPC break point greater than 10 cm, and would therefore not be considered as diagnosed with CI. Based on the convergence insufficiency reading study (CIRS, Table 3)[22] and the division into definite/ high suspect/ low suspect CI that has been adopted by others,[12] patient #1 would be considered high suspect CI, while the other patients would be considered CI. Based on the Cochrane review of CI[6] (Table 3) patients #2 and #3 have convergence reserves lower than 15^{Δ}, whereas patient #1 has convergence reserves that are less than twice the near exophoria (XP) value. Note that if the requirement for convergence reserves was solely twice the amount of near heterophoria, patient #2 would not have been considered CI. In addition, the NPC value of patient #2 is not greater than the threshold value of 6 cm determined by the study.

Interestingly, the studies and textbooks tabulated in Table 3 did not include symptoms associated with CI as part of the diagnostic criteria. Based on the convergence insufficiency treatment trial (CITT, Table 3)[17] diagnostic criteria, all three patients would have been considered symptomatic. Similarly, Kent and Steevev[23] (Table 1) diagnosed CI based on asthenopia unrelated to refractive error alongside reduced convergence ranges. All three patients would have been diagnosed with CI based on this definition. Based on the diagnostic criteria listed in Elsayed and Abdou[24] (Table 3), patient #2 with an NPC of 6 cm would not have been considered CI. Conversely, none of the patients reported diplopia as a symptom, and would not all have been considered CI according to the diagnostic criteria detailed by Ghadban et al.[25] (Table 1). Even if diplopia had been reported by all three patients, only patient #1 has a near heterophoria greater than $10^{\Delta,}$ and would have been regarded as CI.

Symptoms can differentiate between symptomatic and asymptomatic CI.[12] Patients with CISS scores $\geq$ 16 are classified as symptomatic CI, and those with lower scores are classified as asymptomatic.[12,16] Based on this definition, all three patients can be considered symptomatic.

In an effort to address these discrepancies in diagnostic criteria, and to determine the optimal combination of clinical outcome measures for the diagnosis of CI in patients with a large near exophoria and moderate to severe symptoms, Cacho-Martínez and colleagues[26] found that the combination of NPC recovery more remote than 8 cm and binocular accommodative facility less than eight cycles per minute yielded a sensitivity of 0.77, specificity of 1.00, and negative likelihood ratio of 0.23. However, few studies (see Table 1 and 3) list the binocular accommodative facility test as a diagnostic outcome measure for CI, and this information is missing for the patients in Table 2.

Thus, differing diagnostic criteria for CI can yield varying diagnoses in the same patients. Only one study assessed the diagnostic validity of specific clinical outcome measures by calculating their sensitivity and specificity, and examining the receiver operator characteristic curves.[26,27] Researchers and clinicians should carefully assess diagnostic criteria stated in the study methods prior to drawing conclusions regarding treatment efficacy.

Table 1 Prevalence of CI as reported in past studies, in chronological order. The table compares the variation of reported prevalence values, sample size, age range, study setting, and CI definition for each study, if provided.

Study	Prevalence	Sample size	Age range	Study setting	Inclusion criteria - CI definition
White and Brown (1939)[126]	7.5%	11,600	NR*	NR	NR
Duane (1946)[19]	7.5%	NR	NR	NR	Distance orthophoria to slight exophoria(XP), marked near XP, vertical and oblique movements possibly restricted, low fusional convergence, NPC> 7.6 cm, ill sustained convergence
Kent and Steve (1953)[23]	3.7%	4461	17–38	United States Naval Hospital	Asthenopia not related to refractive error, and at least one of the following: convergence ranges break < 3*(XP), convergence ranges break < 15^{Δ}, convergence ranges recovery < 5^{Δ}
Norn (1966)[7]	1.75%	10,022	6–70	Ophthalmologic Practice	Receded NPC > 9 cm
Mahto (1972)[4]	11%	310	<40	Ophthalmologic Practice	Receded NPC > 10 cm (fingertip)
Letourneau et al. (1979)[8]	8.4%	735	7–14	Elementary School	Receded penlight NPC > 10 cm
Pickwell et al. (1986)[11]	14%	643	Adults (age not specified)	Optometric Practice	At least one of the following: NPC > 20 cm (push up), failure on jump convergence between 6 m and 15 cm, or NPC between 10 and 20 cm and the jump convergence slow or hesitant
Letourneau and Ducic (1988)[127]	8.3%	2048	6–13	Elementary schools	Receded penlight NPC > 10 cm on three repetitions, observed deviation of one eye, near XP > distance XP
Deshpand and Ghosh (1991)[45]	7.7%	2162	15–19	Orthoptic Clinic	NR
Dwyer (1992)[128]	33%	144	7–18	Optometric Clinic	Receded accommodative NPC>20 cm or failure of jump convergence between 6 m and 15 cm, or 10 cm < accommodative NPC < 20 cm and slow or hesitant jump convergence
Scheiman et al. (1996)[129]	5.3%	1650	6–18	Optometric Clinic	NPC break > 10 cm or NPC recovery > 17.5 cm, 3 of 10 clinical signs
Porcar et al. (1997)[69**]	7.7%	65	19–25	University students	Symptoms during reading and near XP > 6^{Δ}, (accommodative convergence to accommodation ratio) AC/*A*<3, low near convergence reserves, NPC> 7cm
Rouse et al. (1998)[74]	6% (Definite CI)	620	8–10	Optometric Clinic	near XP ≥ 4^{Δ} + distance phoria; reduced fusional convergence [i.e., failing Sheard's criterion (compensating fusional vergence should be twice the measured phoria)[104] or minimum normative convergence reserves blur/break < 12^{Δ} /15^{Δ}]; NPC break ≥ 7.5 cm NPC recovery≥ 10.5 cm
Rouse et al. (1999)[22]	4.2% (Definite CI)	684	9–14	Recruited from schools and participated in study site	Receded NPC
Lara et al. (2001)[70]	3.5%	265	10–35	Optometric Clinic	These signs: Near XP >6^{Δ}, convergence reserves blur/break/recovery < 11^{Δ} /14^{Δ} /3^{Δ}, NPC break < 10 cm, NPC recovery <17.5 cm, and at least two of the following: AC/*A*<3, binocular accommodative facility test with +200 DS ≤ 3 cpm, MEM < 0.25DS, negative relative accommodation ≤ 1.50 DS.

Table 1 (*Continued*)

Study	Prevalence	Sample size	Age range	Study setting	Inclusion criteria - CI definition
Junghans et al. (2002)[9]	11%	2697	3–12	Elementary schools	NPC $\geq$ 10
Borsting et al. (2003)[3]	12.7% - 2 signs, 4.6% - all 3 signs	392	8–15	Elementary school	At least two: near (30 cm) XP $\geq 4^{\Delta}$ + distance phoria (3 m), cover test, convergence reserve break/recovery $\leq 7^{\Delta}$ / 3^{Δ} or fails Sheard's criteria, using prism bar @ 30 cm, receded push up NPC receded: > 6cm
Abdi et al. (2008)[10]	6%	216	6–16	Elementary school	RAF Rule NPC$\geq$ 10cm
Shin et al. (2009)[71]	20%	1031	9–13	Elementary school	These signs: symptoms, near XP > 6^{Δ},' near and receded NPC $\geq$ 6 cm, Near XP $\geq 4^{\Delta}$ + distance phoria, convergence reserves < Sheard's criterion or <12^{Δ}/15 $^{\Delta}$/4^{Δ} (one); and one of the following: low calculated AC/A ratio, <3, binocular accommodative facility with +2.00 DS $\leq$ 2.50 cpm, negative relative accommodation $\leq$ 1.50 DS
Walline and Johnson-Carder (2012)[75]	17.5%	217	5–18	Eye care practitioner examination forms for children in Individualized Education Programs	near XP $\geq 4^{\Delta}$ + distance phoria, cover test
Horwood et al. (2014)[124****]	10%	167	18–26	University	NPC break $\geq$8 cm, convergence reserves < Sheard's criterion or <12^{Δ}/15 $^{\Delta}$
Jang and Park (2015)[72]	10.3%	589	8–13	Elementary school	These signs: Near XP > 6^{Δ}, convergence reserve blur/break/recovery $\leq 12^{\Delta}/15^{\Delta}/4^{\Delta}$, NPC $\geq$ 10 cm, and at least one: AC/*A*<3, binocular accommodative facility test with +200 DS $\leq$ 3 cpm, MEM < 0.25DS, negative relative accommodation $\leq$ 1.50 DS.
Hoseini-Yazdi et al. (2015)[85]	3.6%	261	< 35	Institutional Optometric Clinic	These signs: high near XP, convergence reserves < $11^{\Delta}/14^{\Delta}$ /3^{Δ} (at least one), NPC break > 10 cm or NPC recovery <17.5 cm; and at least two: low calculated AC/A, failure binocular accommodative facility with +2.00 DS ($\leq$3 cpm), low MEM (<+0.25 D), low negative relative accommodation ($\leq$ 1.50 DS)
Ghadban et al. (2015)[25***]	1.35%	~720 (Based on prevalence estimate of 1/6)	22–97	Retrospectively identified based on resources of the Rochester epidemiology Project (REP), a medical record linkage system over a period of 20 years	Double vision at near and near XP or near XT $\geq 10^{\Delta}$ with orthophoria or small XP at distance
Wajuihian and Hansraj (2016)[12]	4.3% (Definite CI)	1201	13–19	High school	Near XP, near XP $\geq 4^{\Delta}$ + distance phoria, reduced convergence reserves [i.e., failing Sheard's criterion or convergence reserves blur/break $\leq 12^{\Delta}$ / 15^{Δ}, NPC break $\geq$7.5 cm or NPC recovery $\geq$10.5 cm
Davis et al. (2016)[13]	16.7%	484	8–15	3rd-8th graders in school	near XP $\geq 4^{\Delta}$ + distance phoria, NPC $\geq$ 6 cm, convergence reserves < twice the near XP or reserve break /blur < 15^{Δ} All signs: clinical CI First and either second or third sign: common CI

Table 1 (*Continued*)

Study	Prevalence	Sample size	Age range	Study setting	Inclusion criteria - CI definition
Garcia-Munoz et al. (2016)[73]	3.43% (CI only) 1.71% (CI and accommodative dysfunctions)	175	18–35	University	Any visual symptom, near XP $\geq 6^{\Delta}$, and near XP > distance phoria and at least two: convergence reserves $\leq 11^{\Delta}/14^{\Delta}/3^{\Delta}$ (at least one), NPC $\geq$ 6 cm, vergence facility $\leq$ 13 cpm (difficulty with 12^{Δ} BO), binocular accommodative facility < 3 cpm (difficulty with +2.00 D), MEM < 0.25 DS, negative relative accommodation < 1.50 DS
Hashemi et al. (2017)[14]	5.5%	2219	10–69	Stratified cluster population-based study invited to participate in visual examination at University study site	NPC $\geq$ 6 cm, near XP $\geq 4^{\Delta}$ + distance phoria, convergence reserves < twice the near XP or convergence < $12^{\Delta}/15^{\Delta}/4^{\Delta}$, normal Hofstetter's based on amplitude of accommodation
Hussaindeen et al. (2017)[15]	17%	920	7–13	Schools	Two of the following: near XP $\geq 2^{\Delta}$ + distance phoria, receded accommodative NPC break > 6 cm or red filter +penlight NPC break > 12 cm, convergence reserves < 15^{Δ}, difficulty with +2.00 DS binocular accommodative facility < 8 cycles per minute
Menigite and Taglietti (2017)[130]	1.8%	60	40–48	University Professors	Convergence Insufficiency Symptoms Survey (CISS) score> 36
Menjivar et al. (2018)[16]	20%- 2 signs, 6% - all 3 signs	282	9–14	Elementary and Middle school vision screening	near XP (MT) and at least two of the following: near XP $\geq 4^{\Delta}$ + distance phoria, NPC with accommodative target $\geq$ 6 cm, convergence reserves < twice the near XP or reserve break / blur < 15^{Δ}
Hassan et al. (2018)[76]	7.8%	4211	13–18	Secondary school	near XP $\geq 4^{\Delta}$ + distance phoria, NPC $\geq$ 8 cm, convergence reserves $\leq 15^{\Delta}$
Stiebel-Kalish et al. (2018)[77****]	7.7%	39 (Normal cohort)	18–70	Hospital employees and companions accompanying patients	CITT protocol[17] criteria

* Not Reported,.
** CI with accommodative excess.
*** Adult onset CI.
**** Not a prevalence study.

Table 2 Clinical outcome measures for three representative patients.

Patient No.	Age (yrs)/ sex	NPC break with reading glasses (cm)	NPC recovery with reading glasses (cm)	NPC Target Type	Distance Phoria	Near Phoria	Base Out Reserves Blur/Diplopia/ Recovery	CISS
1	55/M	7	7	Small accommodative target (6/9)	Orthophoria	12 XP	0/23/10	30
2	48/F	6	15	Large accommodative target (6/12)	2 EP	2 XP	10/12/8	16
3	49/F	15	30	Large accommodative target (6/12)	2 XP	6 XP	0/12/10	17

Table 3 Diagnostic Criteria of varying studies and textbooks The diagnostic criteria of studies (that are not prevalence studies tabulated in Table 1) and textbooks.

Study	Diagnostic Criteria
Holland[20]	Four criteria: near XP $\geq$ distance phoria, receded NPC, normal to low convergence reserves, ill sustained convergence with BO prisms, symptoms
Scheiman and Wick[21]	near XP > distance, reduced fusional convergence at near, reduced fusional convergence facility at near with BO prisms, receded NPC > 10 cm, low accommodative convergence to convergence ratio (AC/A), failure of binocular accommodative facility with +2.00 Diopter lenses, low monocular estimate method (MEM) amplitude or fusional crossed cylinder (FCC) measurement, reduced ability to release accommodation with positive lenses, and fixation disparity in the exo direction.
CIRS[22]	Definite CI (all criteria): near XP $\geq 4^{\Delta}$ + distance phoria, convergence reserves< 2* near heterophoria or blur value< 12^{Δ} or break value< 15^{Δ}, NPC break >7.5 cm or NPC recovery > 10.5 cm High suspect CI: near XP $\geq 4^{\Delta}$ + distance phoria, and one additional sign Low suspect CI: only near XP $\geq 4^{\Delta}$ + distance phoria
Cochrane review of CI[6]	near XP $\geq$ distance phoria and one additional sign: receded NPC >6 cm or reduced convergence reserves (<15^{Δ} or < 2* near XP value
CITT[17]	Convergence Insufficiency Symptoms questionnaire Score (CISS) $\geq$16, near XP $\geq 4^{\Delta}$ + distance phoria, receded NPC break $\geq$6 cm, convergence reserves < 2* near phoria value, or break value < 15^{Δ}
Elsayed and Abdou[24]	NPC >6 cm, near convergence reserves $\leq 15^{\Delta}$, and symptoms of headaches, asthenopia, and reading difficulty

Even with very clear diagnostic criteria for identification and classification of CI, there is still considerable variability related to the specific clinical measurement techniques and cutoff criteria to be considered abnormal. Testing procedures should be standardized, because varying methods result in different norms and diagnostic values for NPC,[28] heterophoria,[29] AC/A[30], fusional reserves,[31] binocular and monocular accommodative facility,[32] as detailed below.

The following section details different clinical assessments of CI and recommendations (in italics). The recommendations are based on the CITT study,[17] with modifications for older age groups or in areas that are not addressed by CITT with appropriate references provided.

Clinical signs

Near point of convergence

The near point of convergence (NPC) or convergence near point is simple to perform.[33] The target is moved towards the eyes until double vision is reported by the patient, or one eye is observed to move out.[34] This point is recorded as the break point. The target is then distanced from the patient until fusion is recovered, which is recorded as the recovery point.

NPC measurement techniques differ in the type of target used, number of repetitions, break/recovery measurement location, and use of objective observation of the deviating eye vs. subjective report of diplopia.[33]

Target types vary from a pencil tip, fingertip, accommodative target, black line on white background, and penlight.[35] The penlight target has been used alone,[36,37] or in combination with a red lens placed in front of one eye,[36] or red-green anaglyphic goggles.[37]

Although some report that different targets produce varying results,[38] others have reported similar outcomes.[37] Siderov et al.,[39] suggested that the differences in NPC outcomes with target type depends on age. However, Adler et al.[35] found similar outcomes with varying target types in three different age cohorts. Scheiman et al.[37] as well as Benjamin[40] explain that closer NPC break point measurements are obtained with accommodative targets as opposed to non-accommodative targets, due to the reflexive coupling

Table 4 Normative NPC breakpoint (middle column) and recovery (right column) values (in centimeters) reported in studies (left column)*.

Study	NPC Break	NPC Recovery
Davies[2]	7 cm	——
Capobianco[38]	7- 10 cm (penlight)	——
Mahto[4]	10 cm (fingertip)	——
Mohindra and Molinari[118]	15 (penlight or penlight and red lens or penlight and anaglyphic goggles)	17 cm
Pickwell and Hampshire[5]	10 cm (black line)	——
Cohen et al.[131]	10 cm (bell)	——
Helveston et al.[132]	11 cm (accommodative)	——
Hayes et al.[28]	3 cm(K), 4 cm (3rd grade), 4 cm (6th grade) (accommodative)	8 cm (K), 9 cm (3rd grade), 7 cm (6th grade)
Scheiman et al.[37]	5 cm (accommodative), 7 cm (penlight)	7 cm (accommodative), 10 cm (penlight)
Jimenez et al.[133]	3 cm (6 year olds), 4 cm (7), 5 cm (8), 6 cm (9), 6 cm (10), 6 cm (11), 5 cm (12)	9 cm (6 year olds), 11 cm (7), 11 cm (8), 13 cm (9), 11 cm (10), 12 cm (11), 11 cm (12)
Adler et al.[35]	5 cm (fingertip, pencil tip) 6 cm (penlight) 6 cm (accommodative) 9 cm (RAF rule accommodative or line targets)	9 cm (fingertip, pencil tip) 11 cm (penlight) 10 cm (accommodative) 11 cm (RAF rule accommodative or line targets)
Maples and Hoenes[34]	5 cm	——
Abraham et al.[44]	7 cm (13 year olds), 9 cm (22), 10 cm (30) (penlight with red lens)	9 cm (13 year olds), 10 cm (22), 12 cm (30)
Ostagimoghaddam et al.[49]	7 cm (10–19 year olds), 7.5 cm (20–29), 8 cm (30–39) 10 cm (40–49), 11 cm (50–59), 12 cm (60–69), 13 cm (>70)	——

* Values are rounded to the nearest 1.00 cm. Target type used in each study, if specified, appears in parenthesis.

of convergence with activation of accommodation. If differences between penlight and accommodative target NPC measurements are greater than 5 cm for break and 8 cm for recovery, this may indicate presence of CI.[41]

Scheiman et al.[37] reported that the measured NPC of participants with CI change between the first and fifth repetition. Interestingly, the NPC measurements did not vary with repetition for normal adults. Davies[2] recommended repeating the measurement 8–12 times, as results receded after six repetitions. Maples and Hoenes[34] reported significant differences in three consecutive measurements of NPC in normal children, though the differences were not significant clinically. Scheiman and Wick[21] recommend measuring NPC with an accommodative target and then repeating with either a penlight, or penlight with anaglyphic goggles. Carlson and Kurtz[41] recommend performing the initial NPC examination with a penlight and repeating with either a red lens or an accommodative target if the NPC break result is > 5 cm, or the recovery result is > 7 cm. Grosvenor[42] recommend using a penlight, stating the expected normal outcome is ≤ 8 cm from the spectacle plane, and break values of 12–15 cm are considered CI suspect. Benjamin[40] recommends using a non-accommodative target, and an expected outcome of 3 ± 4 cm. He states that a break value > 7 cm, a recovery value > 10 cm, and an increase of at least 3 cm with three repetitions, are suggestive of CI.

The normative NPC break point cutoff value also varies amongst studies. This is another source for discrepancy amongst definitions of receded NPC values that constitute CI. Outcome measures reported in studies during 1926–1991 are comprehensively summarized in Hayes et al. .[28] Other studies not mentioned there and up to 2017 are tabulated below (Table 4).

Finally, another source of discrepancy is the point from which the break and recovery points are determined. While some authors measure the NPC break and recovery points from the forehead/canthus/ nose bridge,[17,40] others measure it from the edge of the nose,[23] the spectacle plane,[8] or even the corneal plane.[43] The Royal Air Force (RAF) rule and Astron International (ACR/21) Accommodative Rule (Gulden Ophthalmics, Elkins Park, PA) with a printed Gulden fixation target that was used in the CITT studies measure the break and recovery points from the forehead.[17] The Beren's Rule that has been adopted for NPC measurements records the break and recovery points from the canthus.[44]

Near point of convergence and age

Many authors report NPC break point varies significantly with age,[44,45] though one study found insignificant differences between the ages of 8 and 13 years.[46] Rosenfield and Logan[43] recommend using an accommodative target and normative break point value of 6 cm for pre-presbyopes with short arms, and 10 cm value for adults. In presbyopes with reduced accommodation, near blur may be confused with diplopia. Therefore, Elliott[47] recommends using a non-accommodative pencil tip in this population and performing

Table 5 Differences in NPC breakpoint values measured in varying age groups (in centimeters)*.

Study	Age Cohort	Mean Difference Between Age Cohorts
Spierer and Hefetz[59]	18–22 vs. 34–38 (same patients)	0.5 ± 1.1 cm
Hayes et al.[28]	K-3rd grade	0.83 cm
	K- 6th grade	1.00 cm
	3rd- 6th grade	0.17 cm
Jimenez et al.[133,*]	6- 12	Up to 2.3 cm
Adler et al.[35]	6–9 vs. 11–13	Up to 1.00 cm, depending on target type
Anderson et al.[103]	7–13 vs. 17–23 (Same patients)	0.30 cm
Jang et al.[46]	8–13	Up to 0.42 cm, depending on the age group
Abraham et al.[44*]	13–22	1.42 cm
	22–30	0.93 cm
	13–30	3.29 cm
Ostadimoghaddam et al.[49]	10–70, striated by decades	Between 1.00–5.00 cm

* Note: For each age group, these differences are smaller than the standard deviation of the measurements.

the test objectively by observing when the eyes break, rather than relying on patient reporting. The CITT used the same NPC break criteria of 6 cm for both the younger 9–17 year old[17] and 18–30 year old cohorts.[48] Table 5 tabulates studies and the reported mean difference in NPC break values with age groups. Mean differences are approximately 1.00 cm, well below the standard deviation of mean NPC value from population-based studies.[28,34,37] A recent large population-based study found significant and large differences (1.00–5.00 cm) in the NPC break value between age groups stratified by decade,[49] possibly due to the lack of exclusion of participants with BV anomalies, or the wider age range that was included (up to age 70, whereas previous studies included up to age 50 years). In fact, the authors note that the largest changes were found between non-presbyopic and presbyopic participants. Finally, the NPC breakpoint was measured either from the spectacle plane or the canthus, and the spectacle plane may underestimate the break point by up to 1.20 cm.[50] This may not be clinically significant, but may account for variances in expected normative values.

These discrepancies highlight the need for clear diagnostic criteria for NPC normative values, the necessity of uniform testing conditions, and the importance of stating experimental conditions in addition to recording the break and recovery distances.

NPC- Recommendation

Based on the CITT protocol, an accommodative 6/9 sized target is recommended for pre-presbyopes, whereas based on Elliott,[47] a penlight should be used for presbyopes. The target should be moved at a constant speed of 1–2 cm/sec towards the patient's eyes as the examiner places a pupillary distance ruler against the nose bridge or outer canthus, while asking the patient to follow the target closely. The breakpoint is the distance from the nose bridge/canthus in which one of the eyes moves out. The recovery point is the distance in which motor fusion is regained. Three measurements should be recorded. A closer breakpoint with increasing measurements indicates that the patient has become better acquainted with the task without convergence issues, whereas a farther break point indicates muscle weakness and raises the suspicion of CI. A breakpoint of 6 cm, similar to the CITT criteria, should be adopted as a cut off criteria for pre-presbyopes, and 10 cm for presbyopes.

Heterophoria

Heterophoria describes the deviation of the visual axes from perfect alignment (fixation) in the absence of fusion.[18] Esophoria (EP), XP, and orthophoria describe axes joining before, behind, and directly on the object of regard, respectively.[29] Heterophoria can be measured using the cover test, von Graefe, Maddox rod, Maddox rod with Thorington card for near,[51] and Maddox Wing for near.[52] The cover test includes two stages, unilateral cover/ uncover and alternating cover. In the unilateral part of the test, the examiner covers one eye and observes the movements of the fellow uncovered eye. If the fellow uncovered eye moves to obtain fixation, this movement compensates for the eye's deviated position. This is considered a strabismus. This process is repeated three times, before the contralateral eye is subsequently covered and the procedure is repeated. If both eyes do not exhibit a compensatory movement, there is no deviation, or strabismus and the patient is considered to have a heterophoria. The amount and the direction of the heterophoria are determined in the alternating cover test. In this test, the examiner alternately covers the eyes to break binocular fusion, while observing the eye that was occluded as soon as it is revealed and the cover moves to the fellow eye. If the eye that was occluded moves to obtain fixation, this means that the eye deviated when it was covered. The deviation can be measured with loose prisms or a prism bar[18,29] as the amount of prism diopter (PD) necessary to neutralize the re-fixational movement.; ~~the~~ The cover test is considered objective because it does not rely on subjective patient responses like other clinical tests.[18,29] It has been shown[53,54] that the clinician's experience affects the results of the cover test and that the examiner endpoint criteria varies amongst individuals.[55]

Most (see Tables 1 and 3) but not all studies[33] require distance and near heterophoria values for the diagnosis of CI. The CITT diagnosis criteria require a near heterophoria at least 4^{Δ} more exophoric than the distance heterophoria, a condition that is met by all cases listed in Table 2. However, the method of measurement of heterophoria may not be consistent amongst studies. Differences in the measured values obtained with varying methods of testing may be insignificant clinically,[29,56] however the methods differ in their variances. For example, the Maddox rod with Thorington card test was found to have better repeatability than the Maddox rod or von Graefe procedures for near heterophoria

testing.[51] Furthermore, varying outcomes are obtained under different conditions such as phoropter ("smooth") vs. prism bar ("step"),[56,57] cover duration,[18] and varying values on the measurement scale (Maddox rod with Thorington card and Maddox Wing) .[52,58]

Heterophoria and age

Some studies report that heterophoria tends to become exophoric with age.[41,59] This tendency may be attributed to the reduction in accommodative amplitude with age.[60] As detailed below, the accommodation and vergence systems are coupled in a reciprocal relationship that is quantified in the AC/A and CA/C ratios.[61,62] Thus, when accommodation is reduced, the accommodative convergence is reduced, resulting is an increased XP. An increase in XP and incidence of CI with age was noted by Pickwell.[63] A study of adult-onset CI in 118 participants over the age of 19 reported an increase of 7^{Δ} of near XP over a 20-year time-period.[25] Other studies report that the near heterophoria value varies with age in children.[64,65] Conversely, constant values of adult distance heterophoria[66] and near heterophoria values in children and adults have also been reported.[65,67,68] Regardless of the effect of age on heterophoria value, the variability of the heterophoria measurement is dependent on the testing method and age of participants, demonstrating significant differences in presbyopic vs. non-presbyopic participants.

Heterophoria- Recommendation

In an effort to maintain maximum objectivity, it is best to perform a prism-neutralized cover test to assess heterophoria at distance and near. Note that if only subjective tests are an option, a Maddox Rod at near with Thorington Card is the optimal choice.[29] Near exophoria values greater than 6^{Δ} [69–73] or that is at least 4^{Δ} more exophoric than the distance value[3,12-14,16,17,22,74-77] or that is decompensated are considered indicative of CI.

AC/A

The AC/A ratio quantifies the amount of convergence obtained for every Diopter of accommodation activated.[78] This can be calculated in the following manner. First, the difference between the near heterophoria and the distance heterophoria values is calculated. This value is multiplied by the near fixation distance, in meters. Then, the inter-pupillary distance, in centimeters is added. The resulting value, is the AC/A ratio.[21] The gradient AC/A is the most common method, which is derived from the difference in the heterophoria value measured with and without spherical lenses, divided by the dioptric value of the spherical lenses.[79] Scheiman and Wick recommend using either −1.00 or −2.00 DS spherical lenses,[21] as implemented in some studies.[80] Others studies used ±1.00 DS lenses,[30] + 3.00 DS,[81,82] or combinations of varying powers.[83] At a fixed testing distance, tonic and proximal vergence are said to remain relatively constant, disparity vergence is minimal due to dissociation between the eyes, and spherical lenses placed in front of the patient alter the accommodative stimulus.[30] The change in measured heterophoria divided by the spherical lens power denotes the AC/A ratio.[21,41] The gradient AC/A ratio is a stimulus rather than a response AC/A, in which the amount of accommodation is *assumed* to correspond to the lens power placed in front of the eyes.[84] The AC/A value has been identified as a distinguishing clinical sign for classifying BV anomalies[21,42]; a low AC/A value has been used as a diagnostic sign for CI by many studies.[69-72,85] As discussed previously, heterophoria values may differ depending on testing method, especially repeated testing which is the foundation of AC/A measurement using the gradient technique.[51,67,86,87] In a study comparing the effects of heterophoria measurement technique on gradient AC/A ratio, the lowest repeatability coefficient was obtained using the Maddox rod with Thorington card (MT) technique with both ±1.00 DS lenses, and the worst repeatability coefficient was obtained with the von Graefe technique with +1.00 DS lenses.[30] A study comparing Howell Phoria Card (similar to MT) gradient AC/A to the response AC/A obtained using a Cannon autorefractor and −1.00 DS and −2.00 DS spherical lenses, reported poor correlation between the two measurements.[80] A low correlation was also reported between the MT stimulus AC/A vs. response AC/A obtained using a Cannon autorefractor, though each method had good intra-test repeatability.[88] The clinical cover test can be used to measure the gradient AC/A[83] and at least one textbook recommends using a heterophoria measurement method that controls accommodation well.[47] However, the use of the cover test has not been compared with the other subjective techniques.

Spherical lens powers can result in variable accommodative responses, yielding varying gradient stimulus AC/A ratios,[89] though one study did not find differences in the response AC/A ratios with varying lens powers.[90]

AC/A and age

AC/A ratio did not vary with age in children 6–14 years[91] and was not different in presbyopes vs. non-presbyopes.[79] However, other studies report that the AC/A ratio increased between the teenage or young adult to pre-presbyopia[90] and presbyopia.[92-95] Rosenfield et al.[96] and Ciuffreda et al.[97] noted that only response AC/A ratio varies with age, and not the stimulus AC/A ratio. Specifically, age was not found to correlate with the stimulus AC/A ratio, though with a clear trend similarly to a small trend reported by Heron et al.[92] in observers above the age of 45 years. Although Bhoola et al.[80] found gradient AC/A correlated with age, the trend was attributed to increasing variability of the measurements with increasing age.

AC/A- Recommendation

Of all sources tabulated in *Tables 1* and *3*, only five referred to AC/A ratio as a diagnostic sign. In the CITT/CITS protocol, AC/A is not included. The relationship between the blur and break points in the fusional reserve test are incorporated in the AC/A ratio. We therefore feel that, although it is relevant to CI, AC/A should not be included as a primary diagnostic sign for CI. Clinicians measuring AC/A for other reasons should use the objective cover test once with +1.00 DS lenses and once with −1.00 DS lenses, then calculate the mean of the two measurements as the gradient stimulus AC/A. For those preferring to use a subjective test, the Maddox rod with Thorington card test was shown to be the most

repeatable of the subjective tests.[30] An AC/A value lower than 3 is considered low and characteristic of CI.[69-72,85]

Convergence reserves (Ranges)

Vergence ranges are measured using either loose ("step") or Risley rotary ("smooth") prisms.[21,31,98] Horizontal vergence ranges can be examined at the base out (convergence) or base in (divergence) directions.[41] A near target is held in front of the patient, imposing activation of a constant amount of accommodation. Prisms are placed in front of the patient's eyes and gradually increased until the patient reports blurring of the target. The blur point denotes the limits of fusional vergence with accommodation held constant Prisms are further increased until the patient utilizes the maximal accommodative vergence, and the target appears double. This is the diplopia point. The examiner reduces the amount of prisms until fusion is regained. This is the point of recovery. Some studies regard the convergence break point as a diagnostic sign for CI whereas others regard the convergence recovery point as a diagnostic sign.[33]

Studies show that the order of prism presentation affects the measurement and recommend the measurement of divergence prior to convergence.[95,98,99]

The type of test method (loose prisms- step vs. rotary prisms- smooth),[31,98] target size,[100] and examiner encouragement[95] also affect the measured outcomes. This could well affect the diagnostic criteria for CI. The CITT[17] protocol used loose prisms and a column of letters size 6/9 (20/30). Loose prism testing represents a more natural environment when compared with the smooth phoropter testing, which may be a reason for implementation of the step (loose prism) method.[101]Clinicians should adhere to one type of testing method for diagnosis and follow-up, as the testing methods are not interchangeable. The repeatability of both methods is better in the divergence as opposed to the convergence direction at both near and distance.[31]

Convergence reserves (Ranges) and age

Fusional reserves have been shown to relate to age and heterophoria value.[102] Although only the recovery and not the break values appear to vary in adults,[66] the convergence break values decrease significantly ($\sim 8^{\Delta}$) with age in myopic children.[103]

Another source of discrepancy for diagnosis of CI is the normative value of the fusional convergence reserves. For example, Porcar et al.[69] did not define the values of the convergence ranges and included anyone with "low" reserves. However, others define reduced convergence reserves as either failure to meet Sheard's criterion (compensating fusional vergence should be twice the measured phoria)[104] or values lower than a set amount which varies among studies. For example, Rouse et al.[22] used break and recovery values lower than $12^{\Delta}/15^{\Delta}$, Lara et al.[70] and Hoseini-Yazdi et al.[105] used values lower than $11^{\Delta}/14^{\Delta}/3^{\Delta}$, Borsting et al.[3] values lower than $7^{\Delta}/3^{\Delta}$; Shin et al. ,[71] Jang and Park,[72] and Hashemi et al.[14] used values lower than $12^{\Delta}/15^{\Delta}/4^{\Delta}$; whereas Kent and Steeve,[23] the CITT study group,[17] Hussaindeen et al. ,[15] Menjivar et al.[16] and Stiebel-Kalish et al.[77] used a break value lower than 15^{Δ}. Davis et al.[13] used 15^{Δ} as the criteria for both break and blur values.

Convergence reserves (Ranges) - Recommendation

BO reserves are sufficient to assess the ability of the motor system to converge, though a thorough examination should include the ranges in both directions, with divergence ranges measured first. The target should include a vertical line of letters or numbers that are two lines larger than the visual acuity of the worse eye. The step method should be used, with the examiner changing the prism power by one step every two-three seconds.[31,98] If the break point is less than twice the value of the measured near heterophoria (not satisfied Sheard's criteria), or lower than 15^{Δ}, the patient has failed this test.

Accommodative amplitude in CI

There is a reciprocal cross-coupling of the accommodation and vergence systems[61,62] which is quantified in the AC/A and CA/C ratios, as described above. Due to the reduced convergence reserves in CI, patients may have been expected to demonstrate high accommodative amplitudes to overcome the lack of convergence by accommodative convergence.[106] However, the studies listed in Tables 1 and 2 do not state accommodative amplitude as an expected diagnostic sign. Furthermore, in their textbooks, Scheiman and Wick state that the expected accommodative amplitude in CI patients is normal.[20] One possible explanation could be the reduced AC/A ratio that characterizes CI[69-72,85] providing little accommodative convergence gain for each Diopter of accommodative effort. The high accommodative effort required to overcome the lack of convergence may be inefficient for the visual system.

Co-morbidity of CI and accommodative insufficiency has been documented, especially in cases of severe CI. However, co-morbidity has been considered a separate entity and not true CI.[107] In addition, CI with reduced amplitude of accommodation that is relieved with plus lenses is also not considered true CI, and has been called *pseudoconvergence insufficiency.*[108]

Binocular and monocular accommodative facility

Accommodative facility is measured by asking the patient to report when the target is clear while the examiner alternates between ±2.00 DS lenses under binocular (BAF) or monocular (MAF) viewing conditions.[21,109] Suppression checks are recommended for BAF testing.[110] The number of alternations, or cycles per minute, is recorded. Normative values of 11 cycles per minute and 7 cycles per minute are typically used for BAF and MAF tests, respectively.[43]The BAF test assesses both the ability of the visual system to activate or release accommodation, as well as the ability to activate fusional vergence to compensate for the activation or release of accommodative convergence.[21] The MAF test assesses only the accommodative system. Thus, if the patient fails the binocular but not the monocular test, the underlying problem is related to the vergence system. Several sources include failure of BAF with +2.00 Diopter lenses as a diagnostic sign for CI.[15,21,70-73,85] If the patient fails both tests, the underlying problem is related to the accommodative system.[21] Results of the accommodative facility tests improve with practice[111] and are influenced by target type,[112] target size,[113] reaction time in alternating

between lenses,[112] and reaction time in patient responses.[114] Thus, relying on BAF and MAF tests for diagnosing CI can be confounded by variations in factors related to testing methodology. Despite this, the combination of BAF with NPC recovery or break values was found to provide the best diagnostic validity for CI in patients with a large near exophoria that suffer from symptoms.[26]

BAF, MAF and age

Perhaps due to the reduction of accommodation with age, normative values of BAF and MAF vary for adults and children as well as adults that are pre-presbyopic vs. presbyopic.[32,109] Amplitude scaled facility incorporates lens powers that are based on the individually measured amplitude of accommodation, and provides a consistent normative BAF value of 10 cycles per minute for all patients.[115] Specifically, the authors recommended a combination of 30% of the lens power and 45% of the testing distance.[115] Unfortunately, MAF values using the amplitude scaled facility test were not investigated.

BAF and MAF – recommendation

Above the age of 13, binocular accommodative facility should be measured based on the push-up amplitude scaled accommodative measurement, combining 30% of the lens power and 45% of the testing distance, with suppression checks,[110] and a normative cut-off value of 10 cycles per minute. As no current evidence exists for the amplitude-scaled MAF method, ±2.00 DS lenses should be used with a cut-off value of 3, 4.5, 5, and 7 cycles per minute for 6-, 7-, 8–12, and 13–30 year olds, respectively.[21,32,109] There is insufficient literature for testing procedures and normative values for patients older than 30 years of age.

Symptoms of CI

Although the majority of the textbooks and studies agree there are symptoms associated with the CI, there is no clinical consensus regarding the symptoms. Von Graefe[116] listed eyestrain, tension in or around the eyes, blurring and occasional diplopia during near work, closing one eye during reading for relieving ocular fatigue, and headaches. Duane[19] described asthenopia, headaches, ocular pain, conjunctival irritation and spontaneous diplopia producing blurred vision at near. Hirsch[117] stated that CI is accompanied by ocular discomfort or fatigue. The most common complaints of his sample of 48 university students with CI included ocular fatigue and general fatigue after sustained near work (38%), headaches after reading (25%), ocular aches/burning/stinging/tearing after near work (18%), and eyelid twitching (4%). However, Hirsch's diagnostic criteria for CI included low amplitudes of accommodation, which likely includes also accommodative insufficiency. As such, these symptoms cannot be attributed only to CI.

Davies[2] described inability to concentrate while reading, distance photophobia, blurring of print, frontal or occipital headaches, nausea and fatigue alongside head retraction, sweating and distress upon request to converge. Kent and Steeve[23] listed the prevalence of symptoms in their clinical population, the majority of which had more than one symptom. The most frequent symptom was headaches (60%), followed by blurring of print (49%), ocular fatigue (34%), occasional diplopia (21%), and other symptoms with unreported frequencies (e.g., nausea, eyelid burning, epiphora, sleepiness during reading, and loss of concentration).

Burian[84] described pain and watering of the eyes, headaches, and asthenopia as a result of near work, and occasional diplopia. Mahto[4] recognized symptomless and symptomatic CI subtypes, with symptomatic CI including eye strain, blurring of text, words running into each other during reading, ocular pain, headaches, and diplopia during near work.

Mohindra and Molinari[118] pointed out that younger children are not expected to complain, and in these cases, clinicians should look for behaviors that may be associated with, or reflect effort to reduce diplopia, such as eyelid rubbing, head shaking, blinking, palpebral narrowing, or closing an eye. For older children and adults they recommend asking about complaints during sustained near work, including horizontal diplopia or running of words in a line.

Others describe symptoms associated with general binocular visual disorders, and not specifically CI. These include asthenopia, headache, blur, and diplopia.[119] A questionnaire assessing the frequency, severity and association of asthenopia was suggested by Sheedy and Saladin[119] in an effort to recognize clinical signs that provide the best indication of binocular visual problems, but was not included in their publication.

Porcar and Martinez-Palomera[69] reported that the most common (8–20 percent) symptoms in 65 university students were asthenopia, headaches, photophobia, and blurred vision either at distance/near/or transition between distances. Less common symptoms (~3%) included diplopia and poor concentration. No correlation analyses with specific or general binocular visual dysfunctions were performed.

Abdi et al.[10] screened 216 school aged children (1st, 4th and 8th grade) for refractive errors, binocular visual functions, and subjective symptoms using a self-reported questionnaire. Questions included fatigue and poor comfort during reading and writing, double vision or loss of words during reading, blurred vision or trouble focusing at/near a computer, and headaches during reading or at the end of the school day. Although 23.1 percent reported asthenopic symptoms, these were not significantly correlated with binocular visual problems and were significantly correlated with low uncorrected visual acuity and myopia.[10]

Westman and Liinamaa[120] retrospectively examined symptoms of 135 patients with CI aged 6–79 years before and after orthoptic treatment. Reported symptoms included difficulty performing near work (69%), headaches (63%), reading difficulty (46%), ocular fatigue (24%), diplopia (21.5%), ocular pain (15%), and watery eyes (3%). Orthoptic exercises eliminated symptoms in 60% of the children (≤18 years of age) and 52% of adults.

The CIRS group found that children with convergence and/or accommodative insufficiency often report symptoms of blurred or double vision, with probability of reporting symptoms increasing with the number of diagnostic clinical signs.[3] They developed the CISS to analyze scope and severity of symptoms in order to diagnose and follow-up improvement with treatment. The questionnaire has been validated in children[121] and adults 19–30 years.[48] The questionnaire comprises 15 questions to which the patient must respond (never, infrequently, sometimes, fairly often, and always) to

provide a total score. The cut off criteria for the CISS varies between children (≥16) and adults (≥21). It has also received wide application for BV disorders other than CI,[122] and been shown to be a general symptoms questionnaire not specific to CI.[123]

One of the difficulties with self-reported symptoms is differentiating between symptoms related to BV anomalies vs. other causes. This was highlighted in a study examining the prevalence of CI and symptomatic CISS scores (≥21) in a sample of 171, 18–26 year old university students[124]; 41 (25%) had symptomatic CISS scores, 11 had CI, but only six of those with CI also had symptomatic CISS scores. The authors concluded that symptomatic CISS scores are common in this population and not indicative of CI, basing their diagnosis of CI on a receded NPC > 8 cm from the bridge of the nose (not 6 cm from the forehead used by the CITT), concurrent with convergence reserves blur/break < 12^{Δ} /15^{Δ}. They excluded participants with large XP at near, without defining a large XP. As such, the authors' definition of CI differs from the definition of CI based on the CITT protocol, and their conclusions do not necessarily apply to the CITT definition of CI.

Symptoms – recommendation
The validated CISS should be used, with the appropriate criteria (>15 for children < 18 and >20 years for adults) to assess symptomatology.

Vergence facility

The facility of the vergence system is examined by rapidly switching between Base Out (BO) and Base In (BI) prisms that are placed in front of the patient's eyes. The prism powers are traditionally 8 $^{\Delta}$ BI and 8 $^{\Delta}$ BO, 5 $^{\Delta}$ BI and 15 $^{\Delta}$ BO, or 12 $^{\Delta}$ BO and 3 $^{\Delta}$ BI.[125] The examiner counts how many times the prism base can be alternated (each alternation is a cycle) during the course of one minute, while the patient is able to fuse and see the text clearly. The combination of 3^{Δ} BI and 12^{Δ} BO for vergence facility testing has been shown to be most repeatable at near.[125] Vergence facility examines the ability of the vergence to rapidly change over time,[125] and those suffering from CI are expected to encounter difficulty in sustaining the BO direction.[21]

Vergence facility – recommendation
Only two sources in *Tables 1 and 2* considered vergence facility as a diagnostic clinical test for CI, and it is not included in the CITT/CITS protocol. Therefore, our recommendation would not be to include it in the diagnostic testing for CI. Clinicians measuring vergence ranges for other reasons should use a combination of 3^{Δ} BI and 12^{Δ} BO mounted on flippers, with a visual target of 6/9 sized optotypes in a vertical column at a distance of 40 cm[125]. A normative value of 15 cycles per minute should be expected. A lower value with difficulty with the BO direction is indicative of CI.

Conclusions

This review highlights several issues with the reported prevalence of CI, stemming mainly from inconsistent guidelines leading to lack of uniformity in diagnostic signs, testing methodology, and cut-off criteria. To illustrate the point, clinical outcome measures of three patients were given. Special attention was given to the effect of age on testing methodology and clinical cut-off criteria. The recommendations put forth in this review are subjective, based on the authors' impressions. However, adaptation by other researchers and clinicians will enable reliability testing for CI incidence, and comparisons among research studies.

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Conflicts of Interest

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