

Others

What is the normative size of the blind spot scotoma in adults?

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Abstract

Enlargement of the blind spot scotoma can be found with papilloedema, caused by raised intracranial pressure, it is important to appreciate that uncontrolled raised intracranial pressure with persistent papilloedema can result in blindness.

The aim of this review is to establish the normative size of the blind spot scotoma in adults. The identified literature is reviewed and discussed in relation to the equipment used to measure the size of the blind spot scotoma. Literature concerning the size of the normal blind spot scotoma was found to be of limited value due to it being old and outdated. Clinicians are forced to rely on information collected on instruments no longer in production and with no standardised unit of measurement.

Clinicians need to have accurate information on the instruments they use to successfully monitor changes in the size of the blind spot scotoma. Further research needs to be conducted using the latest and most accurate equipment providing normative blind spot scotoma size.

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34 Keywords:

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36 Perimetry

37 Blind Spot

38 Scotoma

39 Visual Fields

40 Papilloedema

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43 **What is the normative size of the blind spot scotoma in adults?**

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45 **1.0 Background**

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47 An enlarged blind spot scotoma is indicative of papilloedema alerting
48 clinicians to investigate for raised intracranial pressure. Causes vary from;
49 space-occupying lesions, blockage of the ventricular system, obstruction of
50 CSF absorption, diffuse cerebral oedema, severe hypertension, idiopathic
51 intracranial hypertension (IIH) and hyper-secretion of CSF ^{1,2}.

52

53 Monitoring the size of the blind spot scotoma can indicate progression of
54 disease³. Initially patients may not notice a central scotoma however as the
55 blind spot expands it can affect their central vision. "It is important to
56 appreciate that uncontrolled raised intracranial pressure and persistent
57 papilloedema can result in blindness."⁴.

58

59 To measure the blind spot scotoma a kinetic stimulus is moved from the non-
60 seeing area of the blind spot outwards into the seeing field. Once the target is
61 seen the point is then recorded, this process is repeated in various positions
62 to reveal a scotoma ring within which nothing is seen.

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64 **2.0 Aims**

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66 In order to monitor the change in size of the blind spot it is essential to know
67 the average size of this scotoma in normal subjects. The primary aim of this
68 review is to establish the normative size of the blind spot scotoma in adults in
69 order to aid identification of any scotoma enlargement.

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77 **3.0 Methodology**

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79 This review follows a systematic approach. Fink⁵ described a Research
80 literature review as “a systematic, explicit and reproducible method for
81 identifying, evaluating, and synthesizing the existing body of completed and
82 recorded work produced by researchers, scholars, and practitioners.”

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85 **4.0 Eligibility Criteria**

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87 Although no study designs were to be excluded, Greenhalgh’s hierarchy of
88 evidence was used to prioritise study design⁶. Systematic reviews were
89 prioritised followed by; Randomised controlled trials, Cohort studies, Case-
90 control studies, Cross-sectional surveys and then Case reports.

91

92 All English language and foreign language publications were included, foreign
93 language publications that could be translated into English through available
94 resources were then included in the literature review. Few relevant articles
95 were found so no publication timeframes were imposed. The entire catalogues
96 of publications for each database were searched the most recent studies
97 prioritised. Only studies monitoring human subjects were included.

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100 **5.0 Search Strategy**

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102 The research question was broken down into components that were then
103 used to systematically search each database⁷. These key components were
104 then searched using the advanced search functions of the following
105 databases; Ovid Medline, Ovid SP, Cumulative Index to Nursing and Allied
106 Health Literature (CINAHL), Embase, Google Scholar and the Cochrane
107 Central Library.

108

109 Searches were then conducted of the following individual journals; British
110 Medical Journal, British Journal of Ophthalmology, Journal of Neurology,
111 European Journal of Neurology, Archives of Ophthalmology, American
112 Academy of Ophthalmology, Ophthalmology, Brain (a journal of neurology),
113 and Eye (The Royal College of Ophthalmologists).

114

115 Boolean operators along with Medical Subject Heading's (MeSH) were used
116 to widen the search and pinpoint the articles most relevant to the literature
117 review question. Once relevant articles were found their references were
118 screened and any articles relevant to the review question were investigated.

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120 Unpublished data was also searched, to obtain this grey literature a variety of
121 sources were reviewed. The manufactures of current field analysers were
122 contacted for technical reports. Specialists in the field were contacted and
123 research in progress was discussed. Lectures, seminars and tutorials were
124 requested from Sheffield University and a search of unpublished dissertations
125 and thesis was conducted using the "Networked Digital Library of Theses and
126 Dissertations"⁸.

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129 **6.0 Study selection**

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131 Once duplicates had been removed, a refined literature search showed a total
132 of sixty-four potential articles. The titles and abstracts were then matched

133 against the protocol exclusion criteria. Of these sixty-four articles twenty-one
134 were selected for a full text review.

135

136 From these twenty-one articles fifteen did not provide relevant information to
137 answer the research question these were excluded from the review but kept
138 for future reference. Six articles remained; four prospective cohort studies and
139 two text-books. A Prisma Flow Diagram⁹ is included to aid visualisation of the
140 search process (Figure 1).

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145 **Figure 1.**

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147 **Figure 1.**

148 Prisma Flow diagram

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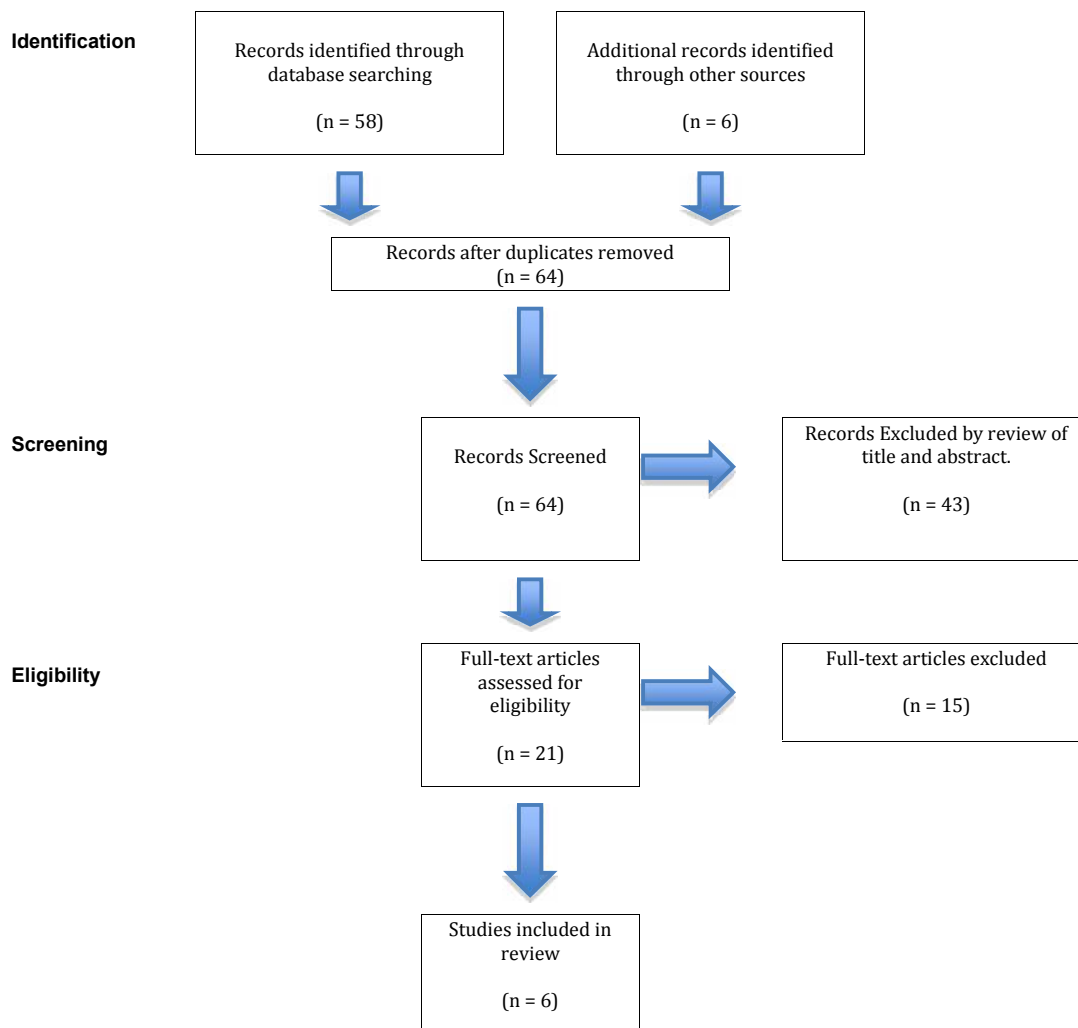
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179 **Included**
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191 **7.0 Quality assessment**

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193 It is essential to assess both the internal validity (bias of the study) and
194 external validity (the amount to which trial results can be applied to other
195 circumstances) of each of the included studies. To quality assess the selected
196 articles a Centre of Evidence Based Medicine (CASP) score will be allocated
197 to each study using the appropriate tools from the CASP website¹⁰. Where
198 possible a risk of bias table highlighting each study's strengths and
199 weaknesses will be made following the examples set by 'The Cochrane
200 Collaboration's tool for assessing risk of bias' ¹¹.

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202 **8.0 Description of Studies**

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204 **8.1 Design & Methods**

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206 This literature review consisted of four prospective studies and two statements
207 from specialist textbooks. The sample population of the prospective studies,
208 Armaly¹², Chamlin¹³, Wentworth¹⁴ and Hopkins¹⁵ consisted of a cohort of
209 'normal patients', all were conducted in the United States of America, subject
210 ethnicity was not recorded.

211

212 Armaly¹² reported a sample population of 210 patients (105 male and 105
213 female), between the ages of 20-65 years. Only one eye was studied from
214 each subject. All subjects had to have a visual acuity measure of 6/6 or
215 greater and a normal ophthalmic examination. Subjects were excluded if they
216 had had any ocular complaint or had a glasses prescription of over one-
217 dioptre spheres of myopia or hypermetropia, likewise if any astigmatism was
218 found of over half a dioptre they were excluded.

219

220 Chamlin¹³ studied eighty-nine eyes from a total of forty-five hospital
221 personnel. The ages were not mentioned. All subjects recorded a visual acuity
222 6/7.5 or greater. Any subject with any evidence or history of fundus disease or
223 disease related to change in the blind spot were excluded.

224

225 Wentworth¹⁴ studied an assortment of nurses, patients and medical staff aged
226 between 14-55 years, no information regarding gender was provided. Two
227 hundred subjects achieving 6/6 vision were chosen, any having 'eye
228 pathology' or 'systemic disease' were not allowed to participate.

229

230 Hopkins¹⁵ studied a population of 100 private patients, the age and gender of
231 these patents were not reported. Hopkins stated that the patients were of
232 normal ocular findings, however he did not list any exclusion criteria.

233

234 Harrington¹⁶ and Traquair¹⁷ produced clinically renowned text books on the
235 visual field, both providing information on the size and location of the visual
236 blind spot. No research study, sample population or methodology is provided
237 to account for this information.

238

239 Each study used different methods to obtain their data most notably the
240 variation in the tools used to measure the blind spot. Armaly¹² used two visual
241 perimeters, both the 1m Tangent Screen with a 1mm target and the
242 Goldmann with a 1-2-e target. Chamlin¹³ also used a 1m Tangent screen with
243 a 1mm target, then a 2m Tangent screen with a 2mm target. Wentworth¹⁴
244 used only a Ferree-Rand perimeter with a 5.8mm target, whilst Hopkins¹⁵
245 used a Steriocampimeter with a 0.68/190mm white target. Neither

Harrington¹⁶ nor Traquair¹⁷ stated the perimeters upon which their measurements of the blind spot scotoma come from.

An overview of the study characteristics can be displayed in Table 1.

Table 1.

Summary of study characteristics.

Author, Year and Country	Study Design	Sample population	Sample Size and Selection	Perimeter (target)	Inclusion	Exclusion
Armaly (1969) USA Iowa City	Prospective cohort	Age 20-65yrs	N = 210 M = 105 F = 105	1m Tangent Screen (1/1000) & Goldmann (1-2-e)	20/20 VA or better Normal ocular examination	Any ocular complaint Ammetropia >1 diopter Astigmatism >0.5 diopter
Chamlin (1960) USA New York	Prospective cohort	Age not reported Hospital personnel	N= 45 (89 eyes) M? F?	1m Tangent (1mm Berens) & 2m Tangent (2mm Berens)	20/25 VA or better	No evidence or history of fundus disease or disease related to change in the blind spot
Wentworth (1931) USA Phila-delphia	Prospective cohort	14-55 years nurses, patients, health care assistants.	N = 200 M? F?	Ferree-Rand With 30 degree Tangent Screen (5.8mm target)	20/20 VA or better	Any eye pathology or Systemic disease

Harrington (1976)	Text book	Not reported	Not reported	Not reported	Not reported	Not reported
Hopkins (1941) USA Brooklyn	Prospective cohort	Age not reported Private Patients	N = 100 M? F?	Stereo-camp-imeter (white targets 0.68/190m)	Normal patients	Not reported
Traquair (1948)	Text book	Not reported	Not reported	Not reported	Not reported	Not reported

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269 8.2 Study bias

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271 Study design quality varied both in terms of methodology and reporting. Table
 272 2 displays the risk of bias for each study, 'The Cochrane Collaboration's tool
 273 for assessing risk of bias' (Cochrane Collaboration, 2012) was used to create
 274 a table appropriate for this review. The final column displays a CASP score,
 275 this was determined using the appropriate CASP checklist¹¹. The checklist
 276 was scored out of 12 with the CASP scores being further broken down into
 277 three categories; 'good', 'can't tell' and 'negative' to further highlight the
 278 studies quality.

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280 **Table 2** - Bias summary, including CASP weighting.

	Study Design	Recruitment (Selection Bias)	Outcome measured to avoid bias (Performance and Detection Bias)	Can the results be applied to the general population (External Validity)	CASP Point Score (+ = good ? = can't tell - = negative)
Armaly (1969)	+	?	+	-	+ = 9 ? = 2 - = 1 9/12
Chamlin (1960)	+	+	+	-	+ = 9 ? = 1 - = 2 9/12

Wentworth (1931)	+	+	+	-	+ = 10 ? = 1 - = 1 10/12
Harrington (1976)	?	?	?	?	+ = 0 ? = 12 - = 0 0/12
Hopkins (1941)	+	-	+	-	+ = 7 ? = 3 - = 2 9/12
Traquair (1948)	?	?	?	?	+ = 0 ? = 12 - = 0 0/12

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282 + = low risk of bias, ? = unclear risk of bias, - = high risk of bias.

283

284 The prospective studies, Armaly¹², Chamlin¹³, Wentworth¹⁴ and Hopkins¹⁵
285 asked clearly focused questions and each had a clear measured outcome.

286

287 Wentworth¹⁴ clearly specified its population recruiting both staff and patients.
288 Hopkins¹⁵ and Chamlin¹³ both used convenience sampling; with Hopkins¹⁵
289 opting for a group of private patients and Chamlin¹³ recruiting hospital
290 personnel. Armaly¹² failed to accurately describe its recruitment strategy, as
291 did Harrington¹⁶ and Traquair¹⁷ the later two failing to provide any
292 methodology in which to gauge study bias.

293

294 The authors of the prospective studies used sound methods in order to limit
295 performance and observer bias to the best of their ability. The results however
296 cannot be easily related to the general population, as the instruments used to
297 obtain these measurements are no longer manufactured or seen in active
298 service in ophthalmology clinics.

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301 9.0 Synthesis of findings

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303 Each study used a different but acceptable method to measure the size of the
304 blind spot scotoma. All works analysed in this literature review; Armaly¹²,

Chamlin¹³, Wentworth¹⁴, Hopkins¹⁵, Harrington¹⁶ and Traquair¹⁷ measured both the height and the width of the blind spot scotoma, Wentworth¹⁴ also provided the area of the blind spot scotoma. A summary of the results can be found in Table 3.

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Table 3. Summary of Study Results

Author, Year and Country	Results			
Armaly (1969) USA Iowa City			R (n=106)	L (n=104)
			<i>Mean (degrees) with standard deviation of the mean.</i>	
	EXAM 1	Tangent Screen 1/1000	Height:10.8±0.13 Width:7.9±0.11	Height:10.5±0.14 Width:7.2±0.10
		Goldmann 12e	Height:14.9±0.18 Width:10.2±0.11	Height:14.6±0.16 Width:9.9±0.10
	EXAM 2	Tangent Screen 1/1000	Height: 10.0±0.13 Width:7.0±0.10	Height:10.3±0.12 Width:7.6±0.10
		Goldmann 12e	Height:13.4±0.19 Width:9.4±0.17	Height:13.4±0.18 Width:9.0±0.13
Chamlin (1960) USA New York	1m Tangent Screen Average height: 7.15±0.39 tangent degrees (138.69±8.78mm) (error 5.5%) Average width: 6.75±0.37 tangent degrees (129.4±7.88mm) (error 5.5%) 2m Tangent Screen Average height: 7.43±0.37 tangent degrees (281.77±14.53mm) (error 5.0%) Average width: 6.87±0.34 tangent degrees (260.7±13.27mm) (error 4.9%)			
Wentworth (1931) USA Philadelphia	Area: 11.4sq cm (range 6.8-17.5 sq cm) (mean deviation of 1.6 sq cm)			

	Width: 3.16cm (2.4-4.3cm range) (Mean deviation of 0.30) Height: 4.56cm (3.6-5.6cm range) (Mean deviation of 0.38)
Harrington (1976)	<i>"The normal blind spot is remarkably constant in position and size. It is vertically oval with steep edges. Its centre is located 15.5 degrees temporal to fixation and 1.5 degrees below the horizontal meridian. It is 5.5 degrees wide and 7.5 degrees high."</i>
Hopkins (1941) USA Brooklyn	Width of blind spot : 25.8mm Height above horizontal fixation point : 7.3mm Height below horizontal fixation point : 19.6mm
Traquair (1948)	<i>"In width it measures approximately 5.5 degrees and in height 7.7 degrees. Its centre lies about 15.5 degrees to the lateral side of the fixation point and 1.5 degrees or slightly more below the horizontal meridian, so that two thirds of its vertical diameter lie below the horizontal meridian."</i>

319

320 Armaly¹² found the Goldmann to measure the size of the blind spot scotoma
321 as larger than that found on the Tangent screen. Sizes were similar when
322 comparing both the right and left eye. Armaly¹² concluded that each test has
323 its own limits and that you could not compare the results of the Tangent
324 screen with that of the Goldmann.

325

326 Chamlin¹³ measured the size of the blind spot scotoma with both the 1m and
327 2m tangent screens. With the 1m Tangent screen the scotoma height was
328 measured as 7.15±0.39 tangent degrees (138.69±8.78mm) and its width
329 6.75±0.37 tangent degrees (129.4±7.88mm). Using the 2m Tangent screen
330 they found the height of the blind spot scotoma to measure 7.43±0.37 tangent
331 degrees (281.77±14.53mm); its width 6.87±0.34 tangent degrees
332 (260.7±13.27mm). Chamlin¹³ found that the percentile error in the mean
333 variant was slightly lower using the 2m Tangent screen, the 2m screen
334 "...giving somewhat more constant and, therefore, more accurate results in
335 measuring the actual size of the blind spot"¹³ see Table 3.

336

337 Wentworth¹⁴ measured the size of the blind spot scotoma in centimetres upon
338 the Ferre-Rand. The Average height was 4.56cm with a mean deviation of
339 0.38, its width 3.16cm with a mean deviation of 0.30. The mean area was 11.4
340 sq cm (mean deviation of 1.6 sq cm).

341

342 Harrington¹⁶ failed to specify the instruments and sample used to determine
343 such results but recorded the size and location of the blind spot scotoma to
344 be; *“The normal blind spot is remarkably constant in position and size. It is*
345 *vertically oval with steep edges. Its centre is located 15.5 degrees temporal to*
346 *fixation and 1.5 degrees below the horizontal meridian. It is 5.5 degrees wide*
347 *and 7.5 degrees high.”*

348

349 Hopkins¹⁵ used the Stereocampimeter to measure the size of the blind spot
350 scotoma and recorded a height of 26.9mm and a width of 25.8mm. No
351 standard deviations were recorded.

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353 Traquair¹⁷ lacked any reporting in terms of methodology but recorded the size
354 and location of the blind spot scotoma as follows; *“In width it measures*
355 *approximately 5.5 degrees and in height 7.7 degrees. Its centre lies about*
356 *15.5 degrees to the lateral side of the fixation point and 1.5 degrees or slightly*
357 *more below the horizontal meridian, so that two thirds of its vertical diameter*
358 *lie below the horizontal meridan.”*

359

360 This review contained four prospective cohort studies and two abstracts from
361 clinically renowned textbooks which measured blind spot scotoma. Although
362 the studies for this literature review comprised of the best literature available
363 they have limited use due to the dated equipment used to measure the blind
364 spot scotoma. Few reports were comprehensive in their details regarding
365 recruitment and five out of six failed to describe the sample population
366 accurately.

367

368 All of the included studies provide information relative to the review question,
369 showing the size of the blind spot scotoma in terms of height and width. All of
370 the literature reports that the scotoma measures taller than it does wide.
371 Wentworth¹⁴ also recorded the area of the blind spot scotoma.

372

373 The results also reiterated Armaly’s¹² conclusion that each test has its own
374 limits and that you could not compare the results of one test with another. This

point is further exemplified in the variety of units used to measure the blind spot scotoma, there has been no standard way of recording the scotoma. This review shows that clinicians need to have accurate information on the instruments they use to successfully monitor changes in the size of the blind spot scotoma.

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387 10.0 Discussion

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Jonas¹⁸ conducted a major review on the evaluation of the optic nerve head, describing the shape of the optic nerve head as “...*being of a slightly vertically oval form, the vertical diameter being approximately 7-10% larger than the horizontal one*”. This blind spot shape corresponds to the literature reviews finding stating that the blind spot scotoma measures taller than it does wide. Hermann¹⁹ measured the mean disc area of the optic nerve head of healthy adults to be 1.82 mm² (SD 0.39).

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Meyer²⁰ also correlated a link between the topography of the optic nerve head and the size of its relative blind spot, however he found that “...*the prominent nasal part of the optic disc appears less ‘blind’ than the shallow temporal part, probably because of more intense light scattering by the prominent nasal part of the disc*”. This implies that one cannot simply assume that the projected blind spot scotoma will be a direct comparison to the size of the optic nerve head.

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This concept can be further complicated by the presence of papilloedema. When investigating patients with papilloedema Corbett (1988) found that with the addition of plus spherical lenses the size of the blind spot scotoma could be reduced, this however was not the case in participants without

409 papilloedema. This is due to the enlarged blind spot being partly due to
410 hypermetropia induced by the elevation of the retina surrounding the swollen
411 optic disc. This alerts clinicians to the need of using a strict protocol that
412 ensure that unwanted manipulation of the blind spot size does not occur.

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414 If papilloedema was suspected from fundoscopy urgent referral would occur
415 regardless of a field result, however in cases where the appearance of the
416 optic nerve head was ambiguous a definitive 'large' or 'outside normal limits'
417 category could certainly aid clinicians taking management decisions. By being
418 able to accurately identify an enlarged blind spot from visual perimetry further
419 grading of papilloedema can be pursued, ensuring prompt referral for further
420 investigation and appropriate interventions.

421 **11.0 Conclusion**

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423 All of the literature included in this review was published between the years
424 1931 – 1976, this reveals a lack in recently published data. A lack of data
425 appropriate for clinical use was identified, no standard way of recording the
426 blind spot scotoma was found and measurements were recorded using
427 equipment that is no longer in production. It appears that clinicians accept the
428 older literature as definitive and may not be aware of the need for further
429 research. In today's world of evidence-based medicine it can never be
430 assumed that our knowledge is complete. Does this literature review provide
431 an example of mythology and tradition surviving from a pre-evidence based
432 past? Further research using this latest and most accurate equipment must
433 be conducted.

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435 **12.0 Limitations**

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437 Certain limitations can be associated with this literature review. A single
438 author conducted all search components including the search, data extraction
439 and quality assessment; this gives rise to the possibility of observer bias. Due
440 to limited resources and funding the literature review was limited to articles
441 published in the English language. Only published data was reviewed, many

442 authors being unavailable to comment due to the age of the publications. This
443 review was not funded and there are no competing interests to disclose.

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