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A visual profile of Queensland Indigenous children.
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# A visual profile of Queensland Indigenous children

**Purpose:** Little is known about the prevalence of refractive error, binocular vision and other visual conditions in Australian Indigenous children. This is important given the association of these visual conditions with reduced reading performance in the wider population, which may also contribute to the suboptimal reading performance reported in this population. The aim of this study was to develop a visual profile of Queensland Indigenous children.

**Methods:** Vision testing was performed on 595 primary schoolchildren in Queensland, Australia. Vision parameters measured included visual acuity, refractive error, color vision, near point of convergence, horizontal heterophoria, fusional vergence range, accommodative facility, AC/A ratio, visual motor integration and rapid automatized naming. Near heterophoria, near point of convergence and near fusional vergence range were used to classify convergence insufficiency.

**Results:** While refractive error (Indigenous: 10%, non-Indigenous: 16%, $p$ = 0.04) and strabismus (Indigenous: 0%, non-Indigenous: 3%, $p$ = 0.03) were significantly less common in Indigenous children, convergence insufficiency was twice as prevalent (Indigenous: 10%, non-Indigenous: 5%, $p$ = 0.04). Reduced visual information processing skills were more common in Indigenous children (reduced visual motor integration [Indigenous: 28%, non-Indigenous: 16%, $p < 0.01$] and slower rapid automatized naming [Indigenous: 67%, non-Indigenous: 59%, $p$ = 0.04]). The prevalence of visual impairment (reduced visual acuity) and color vision deficiency were similar between groups.

**Conclusions:** Indigenous children have less refractive error and strabismus than their non-Indigenous peers. However, convergence insufficiency and reduced visual information processing skills were more common in this group. Given that vision screenings primarily target visual acuity assessment and strabismus detection, this is an important finding as many Indigenous children with convergence insufficiency and reduced visual information processing may be missed. Emphasis should be placed on identifying children with convergence insufficiency and reduced visual information processing given the potential effect of these conditions on school performance.

**Keywords:**

Australian Indigenous children; school children; refractive error; binocular vision; visual information processing; visual impairment

# INTRODUCTION

Australian Indigenous adults have a higher prevalence of low vision (<6/12) and blindness (<6/60) from preventable or treatable eye conditions compared with non-Indigenous Australians[1, 2]; with a recent survey indicating that the relative risk of low vision and blindness in Indigenous adults was 2.8 and 6.2 times higher respectively compared with the wider population.[2] Refractive error (under- or uncorrected) is responsible for approximately half of all vision impairment in Australian Indigenous adults.[2, 3] Only one study, however, has measured the prevalence of refractive error in Australian Indigenous children.[2]

The National Indigenous Eye Health Survey (NIEHS) conducted in 2009 is the largest study to date to examine visual characteristics in Australian Indigenous children, with 1694 Indigenous children (aged between 5 – 15 years) being assessed.[4] The NIEHS used a multi-stage, random cluster sampling methodology; 30 geographic areas were selected from metropolitan, rural and remote regions across Australia.[4] In the NIEHS, 1.5% of Indigenous children had vision impairment (habitual bilateral visual acuity worse than 6/12) and uncorrected refractive error was responsible for 54% of this vision loss.[2] Refractive error, however, was measured only in those children whose unaided visual acuity was less than 6/12 and could be improved with a pinhole. This method has the potential to underestimate the proportion of children with hyperopia and astigmatism. Other causes of vision loss in children assessed as part of the NIEHS were amblyopia, congenital nystagmus and retinal disorders. No other studies have measured refractive error in Australian Indigenous children and very few have assessed the prevalence of binocular vision conditions, color vision deficiency or delays in visual information processing in this group.[5-8] It is important to know the prevalence of vision conditions that have been linked with reduced educational performance in the wider population[9 -11]; given that the gap in literacy and numeracy skills between Indigenous and non-Indigenous school children is known to be substantial, with Indigenous children scoring more poorly than their non-Indigenous peers.[12]

The aim of the current study was to develop a visual profile of Australian Indigenous children and to determine whether differences existed in the prevalence of vision conditions between Indigenous and non-Indigenous children. A primary focus of the study was to determine whether there is a higher prevalence of vision conditions that have been associated with reduced reading ability in the broader population, and may be potentially relevant to the well-established gap in reading performance between Australian Indigenous and non-Indigenous children. A secondary focus was to assist in identifying which vision conditions should be prioritized with vision screenings performed on this group.

## METHODS

Participants were recruited from nine Queensland primary schools via a recruitment flyer posted in the schools' newsletters. Schools were selected based on having a high proportion of Indigenous children attending the school; five schools were from rural Queensland, and four were metropolitan (Brisbane region). The study was designed to collect a representative sample of Indigenous primary school children. Indigenous status was determined via a questionnaire completed by the participant's parent or guardian. Participants were from Years 1, 2, 6 and 7 and were aged between 5 and 13 years. These year levels were selected because of their close alignment with the age of the participants in the Sydney Myopia Study, a large Australian population-based study involving children aged between 6 and 12 years.[13] An experienced optometrist (author SH) conducted all testing in a quiet room at each participating school, with the assistance of trained research assistants.

The study was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Queensland University of Technology Human Research Ethics Committee and the Queensland Department of Education and Training. All participants and their guardians were given a full explanation of experimental procedures. Written informed consent was obtained prior to involvement, with the option to withdraw from the study at any time.

Prior to the day of testing, a questionnaire was distributed to the participant's parent or guardian which covered questions about the child's ocular history, general health (including ear problems and low birth weight), near visual tasks and whether the child had any symptoms of vision problems or asthenopia.

On the testing day, the following vision tests were performed: distance vision assessment, cycloplegic retinoscopy, binocular vision testing and the assessment of visual motor integration and rapid automatized naming ability. Not all participants completed each test, due to either the participant declining to complete a specific test, (most commonly those involving cycloplegia) or due to the varying ability of some children to understand and complete the test; only results for completed tests were included for analysis.

Habitual distance vision was measured monocularly using a 3 metre logMAR chart. Vision impairment was categorized into four levels based on the child's presenting vision: none (≥6/12), mild (<6/12 – 6/18), moderate (6/24 – 6/48,) and severe (≤6/60).[14]

Cycloplegic retinoscopy was performed after administration of Cyclopentolate 1% as a spray to the closed eyelid. The spray application has been shown to produce equivalent cycloplegia to eye drops.[15] Cycloplegia was considered complete when the pupil was both non-reactive to light and had a minimum diameter of six millimetres.[16, 17] Refractive error was classified by its functional significance; myopia as ≥-0.50D and hyperopia as ≥ +2D.[18] A child was considered myopic if one or both eyes had myopia and hyperopic if one or both eyes had hyperopia (in the absence of myopia in the other eye).[19] Anisometropia was defined as a difference in spherical equivalent of one diopter or more between the two eyes. Astigmatism was classified when there was at least one diopter of cylinder in one or both eyes.

The unilateral cover test was used to detect the presence of a strabismus at distance and/or near. The distance target was at 3m, and the near target was held at 40cm. Horizontal phoria, near point of convergence (NPC), fusional vergence range, accommodative facility and AC/A ratio (accommodative convergence to accommodation) were assessed to define the binocular vision function of participants. Horizontal heterophoria was assessed with the Howell-Dwyer phoria card,[20] and the gradient AC/A ratio was determined by measuring heterophoria through plus and minus 2D lenses at 33 cm. Fusional vergence ranges were based on the average of three repeat measures, determined with prism bars (break and recovery), and NPC measurements were also the average of three repeat measures (break and recovery). Both fusional vergence ranges and NPC values were measured with a 6/9 equivalent accommodative target.

Findings from the binocular vision tests outlined above were used to diagnose convergence or divergence insufficiency and excess and basic exophoria or esophoria. The following three criteria were used to classify convergence insufficiency: a near exophoria at least 4Δ more exophoric than at distance, a near point of convergence of ≥ 6 centimetres (break) and either not meeting Sheard's criterion (magnitude of exophoria is greater than half of the positive fusional vergence) or a positive fusional vergence ≤ 15Δ at near (blur or break).[21] In the current study, break point was used for Sheard's criterion (rather than blur point),[22] so that the measurement could be taken objectively, given the age group of the participants. Convergence excess, divergence insufficiency and excess and basic exophoria and esophoria were diagnosed according to Scheiman and Wick's classification criteria for non-strabismic binocular vision conditions.[23]

The Ishihara color vision test was used to detect congenital red-green color vision deficiency. The test was performed under normal classroom lighting conditions, with no additional fixed illumination lamps used for practical reasons. This may be a potential limitation and overestimate the prevalence of color vision deficiency in the sample. A fail criterion of three or more errors on the 16 transformation and vanishing plates was used.[24]

Visual motor integration (VMI), and rapid automatized naming (RAN) were selected as measures of visual information processing and visual to verbal transfer respectively, as both have been previously associated with sub-optimal reading performance.[9, 25-27] VMI describes the ability to integrate visual information with fine motor hand movements and was measured using the Beery-Buktenica Developmental Test of Visual Motor Integration 5th edition. This test was selected as it is a widely used, validated and standardized test.[28] The test requires the child to copy up to 24 geometric shapes onto a recording sheet. The child's raw score was calculated by counting the number of shapes completed correctly before three consecutive failed shapes. Raw scores were then converted to a standardized score.[29]

RAN is a measure of how quickly visually presented stimuli are re-coded into verbal language (named).[25, 26] The vertical subtest of the developmental eye movement (DEM) test was used to assess RAN; it consists of two tests, each comprising two lines of single digit numbers. The vertical subtest is set up on the same principles as the original RAN test.[30] The test is scored by the time taken to read the numbers as well as number of errors made.[31, 32] The DEM test was originally designed to assess horizontal saccadic eye movements in a simulated reading environment. However, one study investigating the validity of the DEM test for measuring horizontal saccadic eye movements with an objective eye movement tracker found that the DEM test did not correlate well with saccadic eye movements, but was related to reading performance and visual processing and verbalisation speed.[31] Subsequently, only the vertical subtest results were analysed in the current study.

*Statistical analysis*

Statistical analysis was performed using SPSS 18.0 (SPSS Inc., Chicago, Ill). For all statistical tests, a value of $p < 0.05$ indicated a statistically significant difference. Categorical variables were compared between Indigenous and non-Indigenous cohorts using chi-square tests, and continuous variables were assessed using *t*-tests.

## RESULTS

Five hundred and ninety five children participated in this study. The participation rate at the first schools visited was relatively high, with 84% of Indigenous children enrolled in the selected year levels participating in the study. Sample characteristics, organized by Indigenous status, gender and age group, are presented in Table 1.

Only one Indigenous child (0.6%) presented with vision impairment in both eyes (R: 6/19 and L: 6/15, suspected to be due to bilateral amblyopia), compared with 7 (1.7%) of the non-Indigenous children; this difference was not significant, $\chi^2_1 = 1.23$, $p = 0.27$.

The spread in spherical refractive errors was greatest amongst non-Indigenous children; none of the Indigenous children had moderate or high myopia or high hyperopia (see Figure 1). Indigenous children had a significantly lower rate of overall refractive error; 9.6% had refractive error in at least one eye compared with 16.1% of the non-Indigenous children. The prevalence of the different refractive errors by Indigenous status is presented in Table 2.

None of the Indigenous children had strabismus at distance or near. Of the non-Indigenous children, 2.7% and 3.0% had distance and near strabismus, respectively (distance: $\chi^2_1 = 4.77$, $p = 0.03$; near: $\chi^2_1 = 5.01$, $p = 0.03$).

Of the children with refractive error, 17.6% of Indigenous children had been prescribed spectacles at some stage previously as reported in the questionnaire (however, none of the children had their glasses with them at school on the day of testing), compared with 20.7% of non-Indigenous children, $\chi^2_1 = 0.08$, $p = 0.78$. Sixty percent of the non-Indigenous children who had been prescribed glasses previously had them with them at school. In comparison to the refraction found on the day, 50% of children had spectacles within 0.50 diopters, and the remaining 50% had refractions that were different to this by at least 0.75 diopters.

There was no difference in color vision deficiency (CVD) between Indigenous and non-Indigenous boys; 4.5% of Indigenous boys had a CVD compared with 4.4% of non-Indigenous boys, $\chi^2_1 = 0.01$, $p = 0.98$.

The findings with regard to non-strabismic binocular vision conditions are presented in Table 3. Non-strabismic convergence insufficiency was twice as common in Indigenous children, while more non-Indigenous children were classified with a basic esophoria. Individual results for the binocular vision parameters used in the diagnostic criteria of convergence insufficiency (near point of convergence, positive fusional vergence at near and horizontal heterophoria) have been presented in Figures 2 – 4.

Reduced VMI and reduced RAN skills were more common in Indigenous children. The mean VMI standardized score was significantly lower in Indigenous children (Indigenous: 92.69 ± 13.86, non-Indigenous: 98.37 ± 14.76; $t(586) = -4.37$, $p < 0.01$). The mean standardized score reported in the Beery VMI manual is 100 with a standard deviation of 15.[29] A higher percentage of Indigenous children had a VMI standardized score that was more than one standard deviation below the mean (that is a score of 84 or less), $\chi^2_1 = 10.75$, $p < 0.01$; 28.09% of Indigenous children had a VMI standard score of 84 or less, compared with 16.34% of non-Indigenous children.

The mean time taken to complete the two vertical subtests on the Developmental Eye Movement test for Indigenous and non-Indigenous children was used as a measure of RAN in this study. Raw scores were converted to a percentile rank (which takes into account the child's school year level). The mean percentile rank was significantly lower in Indigenous children (Indigenous: 17.71 ± 26.23, non-Indigenous: 23.00 ± 28.04; $t(576) = -2.12$, $p = 0.03$).

## DISCUSSION

This is the first study to present a comprehensive visual profile of Australian Indigenous children, and compare this with that of their non-Indigenous peers. Significant between group differences were found in refractive error, binocular vision and visual information processing ability.

There was a lower rate of refractive error in the Indigenous compared to the non-Indigenous children. The NIEHS reported an overall prevalence of refractive error of 8.7% in Indigenous children, which is slightly less than that found in the current study of 9.6%.[33] However, in the NIEHS, refractive error was only measured in those children whose unaided visual acuity was less than 6/12 and could be improved with pinhole, but was measured in all children in the current study. The prevalence of different types of refractive errors (myopia, hyperopia and astigmatism) within Indigenous children was not reported in the NIEHS. Our study was the first to perform cycloplegic retinoscopy on Indigenous children to characterize refractive error.

Spectacle wear in the current study was much lower than that found in the Sydney Myopia Study (a large study performed on Sydney school children). In the Sydney Myopia Study, spectacles were worn by 54.7% of twelve year old children with clinically significant refractive error in at least one eye compared with only 17.6% of Indigenous children and 20.7% of non-Indigenous children in the current study.[34] Conversely, spectacle wear was much lower in Indigenous children in the NIEHS where only 8% of children with refractive error had spectacles.

A difference in sample demographics is also likely to explain the disparity in spectacle wear. Children in the Sydney Myopia Study would have had better access of eye care services due to their closer proximity to metropolitan centres compared to the children in the current study which comprized of children from both metropolitan and rural areas. In the NIEHS, a number of remote communities were included; in these communities only limited optometric services and subsequent dispensing of spectacles were available.

Strabismus is the only binocular vision condition in Australian Indigenous children that has been investigated previously. In one study from the Northern Territory, school screening results revealed that less than one percent of Indigenous children had strabismus.[5] Two other studies have also reported a low prevalence of strabismus in Indigenous Australians. In the National Trachoma and Eye Health Project, the prevalence of esotropia and exotropia in Indigenous adults was 0.2% and 0.5%, respectively,[35] while in a study on Indigenous adults from the Western Desert region, of the 804 people assessed, there were no cases of convergent strabismus; the prevalence of divergent strabismus was not, however, reported in that study.[6] These studies support the findings from the current study, where no Indigenous children were observed to have strabismus. It is possible that intermittent strabismus was underreported in the current study, given that the cover test was only performed once, and in morning sessions only. Furthermore, had the distance cover test been performed using a target further than 3 metres away, more divergence excess type exotropia may potentially have been found. These methodological limitations would however have affected the findings for Indigenous and non-Indigenous children equally and the difference between groups remains relevant. Furthermore, the results for the non-Indigenous group compare closely to those of the Sydney Myopia Study, where 2.8% of children had strabismus.[36] Other studies have also found differences in the prevalence of strabismus depending on ethnic background, with esotropia being less common in children of a non-white ethnic background.[37, 38]

Convergence insufficiency (CI) was twice as common in Indigenous children compared with non-Indigenous children. This finding is important due to the previously reported association between binocular vision conditions and reduced reading ability[39]; particularly given the gap in reading performance between Indigenous and non-Indigenous children, in which fewer Indigenous children are meeting minimum national standards in literacy and numeracy.[12, 40] The reported prevalence of CI varies widely in the literature, ranging from 1.8% to 83%.[10, 41-43] Differences in the definition of CI, criteria used for diagnosis, methods of measurement and differences in characteristics of the population are likely to account for differences in prevalence of CI reported between studies, however, ours is the first to identify differences in CI prevalence between ethnic groups within a single study. In one study that used the same classification system for CI as the current study, no difference in CI existed between children of different ethnic backgrounds. The prevalence of CI was between 4 – 5% in Caucasian, African American, Hispanic and Asian-Pacific children; this prevalence is similar to the results for non-Indigenous children in the current study,[41] and much less than that found in Indigenous children. Further investigation of the functional impact of convergence insufficiency on educational outcomes in Indigenous children is warranted, as well its association with asthenopia, concentration span and fatigue. Measuring symptom levels with a standardized symptom survey would be one method of determining the association between convergence insufficiency and these factors and would help establish the importance of its early detection and management in Indigenous children.

It is more difficult to directly compare the findings for the remaining non-strabismic binocular vision conditions investigated in this study. The prevalence of vergence dysfunctions has not been reported extensively in the literature (with the exception of convergence insufficiency), with comparisons between studies even less frequent due to differences in diagnostic criteria and sample population.[44] The small number of studies that have reported on vergence dysfunctions, however, have shown convergence excess and basic esophoria to be more common than basic exophoria and divergence excess.[44, 45]

Reduced VMI and RAN ability were more common in Indigenous children. VMI and RAN have not been investigated previously in Australian Indigenous children. This is an important gap in the literature given the association that both of these skills have with reading ability in the broader population of primary school children and the known disparity in reading outcomes between Indigenous and non-Indigenous children.[9, 46]

The overall mean VMI standard scores in the current study were lower than the expected standard score of 100 (Indigenous: 92.7 and non-Indigenous: 98.3). This reduced performance may be due to the fact that all children attended schools located in areas of low socioeconomic status, given that lower socioeconomic background has been associated with reduced VMI.[47-49] Other tests of VMI (Developmental Test of Visual Motor Integration and Perception) have also been shown to be affected by ethnic background as well as language background.[47, 50] Further investigations should determine whether the design of these tests is appropriate for detecting differences in VMI between ethnic groups.

Reduced RAN skills have been associated with language difficulties in children who experience problems in this area.[51] A language background other than English may also be associated with poorer RAN scores, as the child's ability to perform the vertical subtests of the DEM may be affected. Many of the children in the current study had a language background other than English. This may have been because the schools were in low socioeconomic areas and tended to include high migrant populations. Furthermore, Indigenous children may speak another language at home. These language-related factors may explain why the mean percentile ranks were low for both groups. However, information regarding the language and ethnic background of the non-Indigenous children was not recorded, which is a potential limitation of the current study.

Another limitation of the study is the population sampling. The participation rate for Indigenous children in the current study (84.1%) was similar to that reported by the NIEHS (84.4%). Similar challenges with recruitment were experienced in both studies.[4] It was noted in the NIEHS that visiting sites prior to data collection assisted with recruitment. In the current study, multiple visits to schools by the principal investigator were undertaken several weeks before the data collection period to explain the study in detail. This allowed the school liaison officer sufficient time to disseminate the details of the research to the school community. This decision facilitated relatively high recruitment rates, as it has been previously shown that Indigenous people are more willing to participate in studies if approached by their peers, rather than researchers.[52] Future research with Indigenous children would also need to factor in the additional consultation time required with the school and/or community to ensure adequate recruitment rates are achieved.

Despite the high participation rate in this study, it is possible that children who did not participate chose not to do so because they were already being treated for an eye condition, and did not see the need for further optometric assessment. This potential sampling bias would result in the underreporting of eye conditions within this population.

There are a number of findings from the current research which add substantially to existing knowledge regarding Australian Indigenous children's vision, particularly as there are only a limited number of studies that have measured visual function in this group.[5, 6, 33, 35, 53] This study is the first to report the prevalence of refractive error, strabismus, accommodation and/or vergence disorders, delayed visual information processing skills (RAN and VMI) and color vision deficiency in Australian Indigenous children. Understanding which vision conditions are more common in Indigenous children will assist eye care practitioners in their visual assessment of this group. Refractive error and strabismus were less common in Indigenous children, whilst convergence insufficiency was found to be twice as common. Thus eye care provision for these children needs to incorporate appropriate testing to allow for classification of convergence insufficiency, such as measurements of near point of convergence, horizontal phoria and fusional vergence range.

In summary, a detailed visual profile of a group of Queensland Indigenous primary school children is provided by the current study. This demonstrates that Indigenous children have less visual impairment (based on reduced visual acuity), less clinically significant refractive error and less strabismus than their non-Indigenous peers but relatively high levels of CI, and poorer VMI and RAN. This is an important finding given that conventional vision screenings which target visual acuity assessment and strabismus detection are unlikely to identify the visual problems of Indigenous children.

In addition, our finding of poorer visual information processing skills is relevant given their association with reading ability and may be one of the factors underlying the previously established gap in literacy outcomes between Indigenous and non-Indigenous children.

Future research should investigate the functional effect of reduced RAN and VMI on educational outcomes in Australian Indigenous children. This would assist in determining the relative importance in developing appropriate interventions and management strategies targeting these conditions in this group.

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**Table 1:** Number of children (%) grouped by Indigenous status, age group and gender

| | | Total (n, % of total sample) | Indigenous (n, %) | Non-Indigenous (n, %) |
|---|---|---|---|---|
| *Indigenous status* | | 595 (100.0%) | 181 (30.4%) | 414 (69.6%) |
| *Age group* | Years 1 and 2 | 312 (52.4%) | 105 (33.7%) | 207 (66.3%) |
| | Years 6 and 7 | 283 (47.6%) | 76 (26.9%) | 207 (73.1%) |
| *Gender* | Male | 295 (49.6%) | 90 (30.5%) | 205 (69.5%) |
| | Female | 300 (50.4%) | 91 (30.3%) | 209 (69.7%) |

**Table 2:** Prevalence of refractive error (%) by Indigenous status in at least one eye

| | Indigenous | Non-Indigenous | Chi-square, *p*-value |
|---|---|---|---|
| *Any refractive error* | 9.6% | 16.1% | $\chi^2_1 = 4.23, p = 0.04$ |
| *Hyperopia (≥ 2.00D)* | 5.1% | 8.1% | $\chi^2_1 = 1.61, p = 0.20$ |
| *Myopia (≥ 0.50D)* | 1.7% | 4.0% | $\chi^2_1 = 2.07, p = 0.15$ |
| *Astigmatism (≥ 1.00D)* | 3.4% | 1.9% | $\chi^2_1 = 1.18, p = 0.28$ |
| *Anisometropia (≥ 1.00D)* | 4.0% | 5.7% | $\chi^2_1 = 0.96, p = 0.33$ |

*Refractive error was measured in both eyes of 537 children, and in one eye only of an additional 12 children. Cycloplegia was either contraindicated, or declined in the remaining 46 participants.

**Table 3:** Percentage of Indigenous and non-Indigenous children with non-strabismic binocular vision conditions; significant differences are in bold text

| | Indigenous | Non-Indigenous | Chi-square, *p*-value |
|---|---|---|---|
| *Convergence insufficiency* | 10.3% | 5.2% | $\chi^2_1 = 4.15$, $\mathbf{p = 0.04}$ |
| *Convergence excess* | 5.4% | 5.4% | $\chi^2_1 = 0.00, p = 0.99$ |
| *Divergence insufficiency* | 1.7% | 4.7% | $\chi^2_1 = 3.96, p = 0.05$ |
| *Divergence excess* | 4.8% | 8.8% | $\chi^2_1 = 2.36, p = 0.13$ |
| *Basic exophoria* | 2.1% | 4.1% | $\chi^2_1 = 1.34, p = 0.25$ |
| *Basic esophoria* | 0.7% | 4.1% | $\chi^2_1 = 4.09$, $\mathbf{p = 0.04}$ |

## Figure legends.

*Figure 1:* Range of spherical refractive errors for Indigenous and non-Indigenous children (%)

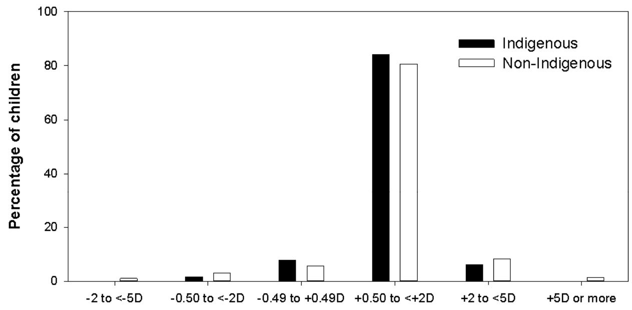


*Figure 2:* Box plots for NPC break point (centimetres)

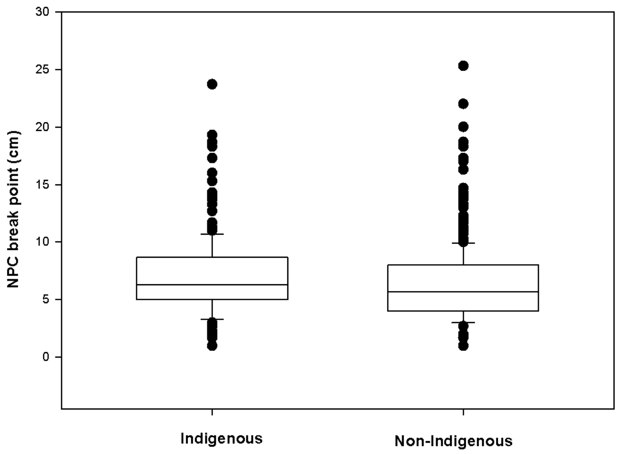


*Figure 3:* Box plots for positive fusional vergence at near

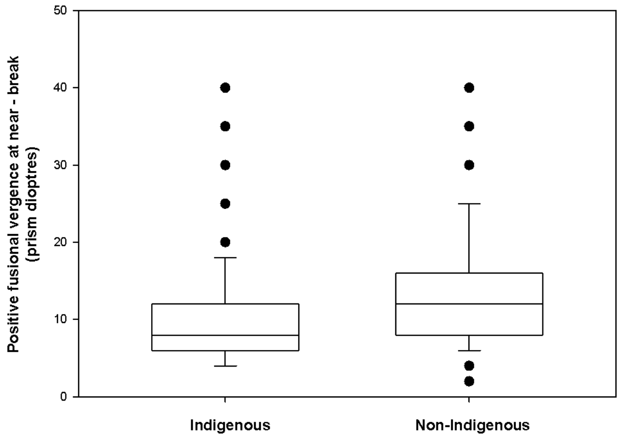


*Figure 4:* Box plots for near horizontal heterophoria (positive values represent exophoria)