Non-cycloplegic refraction cannot replace cycloplegic refraction when screening for refractive errors in children

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Abstract

The purpose of this study was to assess the differences in spherical equivalent refractive error (SER) assessed by commonly used screening methods: cycloplegic autorefraction (1% cyclopentolate), non-cycloplegic autorefraction, and non-cycloplegic retinoscopy in a population with a high prevalence of hyperopia. Refractive error was measured with the three methods in 111 children aged 7–8 and 10–11 years. Bland-Altman analysis was used to assess the mean of the differences (*MD*) and the 95% limits of agreement (LoA) between cycloplegic autorefraction and the two non-cycloplegic methods. A mixed effects model was used to investigate the differences between methods by refractive group. Cycloplegic autorefraction gave a significantly more positive SER than both non-cycloplegic retinoscopy ($MD = 0.47$ D, LoA = −0.59–1.53 D) and non-cycloplegic autorefraction ($MD = 0.92$ D, LoA −1.12–2.95 D). The mean differences in SER increased with increasing degree of hyperopia [$F(4, 215) = 12.6$, $p < 0.001$], both when comparing cycloplegic refraction with non-cycloplegic retinoscopy and non-cycloplegic autorefraction.

Non-cycloplegic retinoscopy and autorefraction result in significantly less positive SER than cycloplegic autorefraction. The wide confidence intervals for the mean difference and limits of agreement are clinically unacceptable and the methods cannot be used interchangeably. Consequently, refraction without cycloplegia would cause misdiagnosis in some children. Even if non-cycloplegic retinoscopy results in narrower limits of agreement, the risk of misdiagnosis is not eliminated by being experienced in carrying out retinoscopy. We show that it is essential to use cycloplegia when refracting children, particularly in a population with a high prevalence of hyperopia, to ensure that no hyperope goes undetected.

Keywords: Children, cycloplegic autorefraction, non-cycloplegic autorefraction, non-cycloplegic retinoscopy, cyclopentolate

Introduction

The clinical value of cycloplegia is often overlooked by practitioners, who frequently omit its use during refraction, which may lead to an underestimation of hyperopia or overestimation of myopia (e.g. (Doherty et al., 2019; Fotedar et al., 2007; Sun et al., 2018; Zhao et al., 2004)). In children, cycloplegic refraction is considered essential in epidemiological studies and the gold standard in clinical practice (American Optometry Association, 2017; Morgan et al., 2015). It is known that uncorrected refractive errors can affect daily life and academic achievement (Kulp et al., 2016; Mavi et al., 2022; Neitzel et al., 2021; Williams et al., 2005), and hence it is important that refractive errors are detected, accurately assessed, and corrected when needed. The most common refractive error in children in Norway, Sweden, and Denmark is hyperopia (Demir et al., 2021; Hagen et al., 2018; Sandfeld et al., 2018), which is different from that reported in children from South-East Asia, East Asia, and the Western Pacific region (Hashemi et al., 2018).

In a review, L. B. Wilson et al. (2020) showed that there is good agreement between cycloplegic autorefraction and cycloplegic retinoscopy, but non-cycloplegic autorefraction had a propensity to give more negative results than cycloplegic autorefraction in children. Few studies have compared retinoscopy with and without cycloplegia in school-aged children. A Northern-Irish study of children aged 6–13 years revealed more positive refraction in all age groups when comparing cycloplegic with non-cycloplegic retinoscopy, with a mean difference of 0.59 D (Doherty et al., 2019). The greatest difference was found for the younger children and children with higher degrees of hyperopia. The same study reported non-cycloplegic hyperopia of ≥ +1.5 D to have high sensitivity and specificity for revealing clinically significant hyperopia (≥ +2.5 D after administering 1% cyclopentolate). A Norwegian study found significantly higher degrees of hyperopia (0.5 D) after cycloplegia (cyclopentolate 1%) in children aged 10–15 years (Thorud et al., 2021). Some studies have found good inter- and intra-repeatability of cycloplegic retinoscopy in children for experienced clinicians (Hirsch, 1956; McCullough et al., 2017), although cycloplegic autorefraction typically gives higher repeatability than cycloplegic retinoscopy (Fotouhi et al., 2012; Nilsen et al., 2022; Sankaridurg et al., 2017; Zadnik et al., 1992). Clinical studies show considerable between-individual variation when non-cycloplegic and cycloplegic refraction methods are compared (L. B. Wilson et al., 2020).

It is essential to know the cycloplegic refractive error prior to deciding the best treatment option, especially when dealing with children with hyperopia, amblyopia, and binocular and accommodative dysfunctions. Further, the need for more research concerning differences between non-cycloplegic and cycloplegic refraction for different refractive errors in different age groups was pointed out in a recent systematic review (S. Wilson et al., 2022). The purpose of this study was to assess differences in commonly used screening methods for assessing refractive errors; non-cycloplegic retinoscopy performed by an experienced optometrist, non-cycloplegic autorefraction, and cycloplegic autorefraction in primary school children in South-East Norway. Importantly, this study contributes to increasing knowledge about differences in cycloplegic and non-cycloplegic refraction in children in a population where the prevalence of hyperopia is high.

Materials

Study population, recruitment, and participants

A cross-sectional study was performed in 2020 and 2021 for children aged 7–8 and 10–11 years in a primary school in Kongsberg Municipality, as part of a school vision testing program run by The National Centre for Optics, Vision and Eye Care (NCOVE) at the University of South-Eastern Norway. All children were invited, and 111 children (50%) participated. The ethnicity of the children was not recorded, but the majority were Caucasian. The population of Kongsberg is ethnically and socio-demographically representative of Norway (see additional information of Hagen et al. (2018)). Written informed consent from both parents was required for inclusion in the study. Written and oral explanations of the purpose and the procedures of the study were given and approved by the Regional Committees for Medical and Health Research Ethics (REC) in South East Norway. The research was conducted in accordance with the tenets of the Declaration of Helsinki.

Procedures

Non-cycloplegic retinoscopy was obtained by two optometrists with more than 20 years experience of performing retinoscopy in children. A standard retinoscopy procedure was performed through a +1.5 D lens using a manual phoropter, neutralising the spherocylindrical refractive error. The children viewed a large letter or another suitable non-accommodative object at a distance of at least 6 metres. Non-cycloplegic and cycloplegic autorefraction were performed utilising the Huvitz HRK-8000A Auto-REF Keratometer (Huvitz Co. Ltd., Gyeonggi-do, Korea), which has been shown to have high repeatability (Nilsen et al., 2022). Results from autorefraction were automatically calculated from five measurements. The cycloplegic autorefraction was done 30–40 minutes after administering Cyclopentolate 1% (Minims single dose; Bausch & Lomb UK Ltd., Kingston, England). Children with blue or green eyes received one drop, whereas those with hazel to brown eyes received two drops in each eye.

Analyses

Spherical equivalent refractive error (SER) was calculated (SER = sphere + ½ cylinder). Myopia was defined as SER $\leq$ -0.50 D, emmetropia as -0.50 D $<$ SER $<$ $+0.50$ D, low hyperopia as $+0.50$ D $\leq$ SER $<$ $+2.00$ D, and moderate-to-high hyperopia as SER $\geq$ $+2.00$ D. Refractive astigmatism was defined as $\geq$ 0.75 DC. Mean, standard deviation (*SD*), and total range for retinoscopy, and autorefraction with and without cycloplegia were summarised for all participants and the two age groups. Cycloplegic autorefraction was used to investigate the frequency and distribution of refractive errors. A Welch two-sample *t*-test was used to assess mean cycloplegic refractive error for each age group. Boxplots and Bland-Altman plots with 95% limits of agreement (LoA) and 95% confidence intervals (CI) were used to assess the agreement between cycloplegic autorefraction and the two non-cycloplegic methods. A linear mixed model analysis of variance and post hoc pairwise comparisons, based on model estimated marginal means and standard errors (*SE*), were used to analyse the mean differences in SER between refraction methods by refractive group. To obtain a sufficient number in each group, the myopia and emmetropia group were combined. The *p*-values were adjusted for multiple comparisons using Bonferroni correction. A statistical difference was set to $p < 0.05$ (two-tailed). Statistical analyses were performed in R statistical software version 4.2.1 (R Core Team, 2021), including the package lme4 version 1.1-30 (Bates et al., 2015).

Results

In total, 111 children participated (45% females), 53 (48%) were aged 7–8 years, and 58 (52%) were aged 10–11 years. There was no difference in mean cycloplegic SER between the right and the left eye ($t(110) = -0.26$, $p = 0.80$), thus the right eye was used for further analyses. Table 1 shows the demographic and cycloplegic refractive error data. Of the children aged 7–8 years, 94% had hyperopia, 2% had emmetropia and 4% had myopia. Of the children aged 10–11 years, 88% had hyperopia, 10% had emmetropia and 2% had myopia. The mean cycloplegic refractive errors for the children aged 7–8 years and 10–11 years were +1.27 ± 0.75 D and +1.40 ± 1.58 D, respectively, and reflect a higher number of high hyperopes among the 10–11-year-olds (see Table 2). There was no statistically significant difference in mean SER between the age groups ($t(82.87) = -0.57$, $p = 0.57$), nor between males and females ($t(107.08) = 0.72$, $p = 0.47$) for either age group (7–8 years ($t(50.44) = 1.60$, $p = 0.17$), 10–11 years ($t(55.91) = 0.10$, $p = 0.91$)).

Comparison of refractive methods

Figure 1 shows Bland-Altman plots for comparison between cycloplegic autorefraction and the two non-cycloplegic refraction methods. The mean difference (95% CI) between cycloplegic autorefraction and non-cycloplegic retinoscopy was 0.47 D (0.37, 0.57) with 95% LoA (95% CI) -0.59 D (-0.77, -0.42) to 1.53 D (1.35, 1.70). The mean difference (95% CI) between cycloplegic and non-cycloplegic autorefraction was 0.92 D (0.72, 1.11) with 95% LoA (95% CI) -1.12 D (-1.45, -0.78) to 2.95 D (2.61, 3.28). The wide LoAs indicate a larger individual difference between cycloplegic and non-cycloplegic autorefraction (see Figure 1).

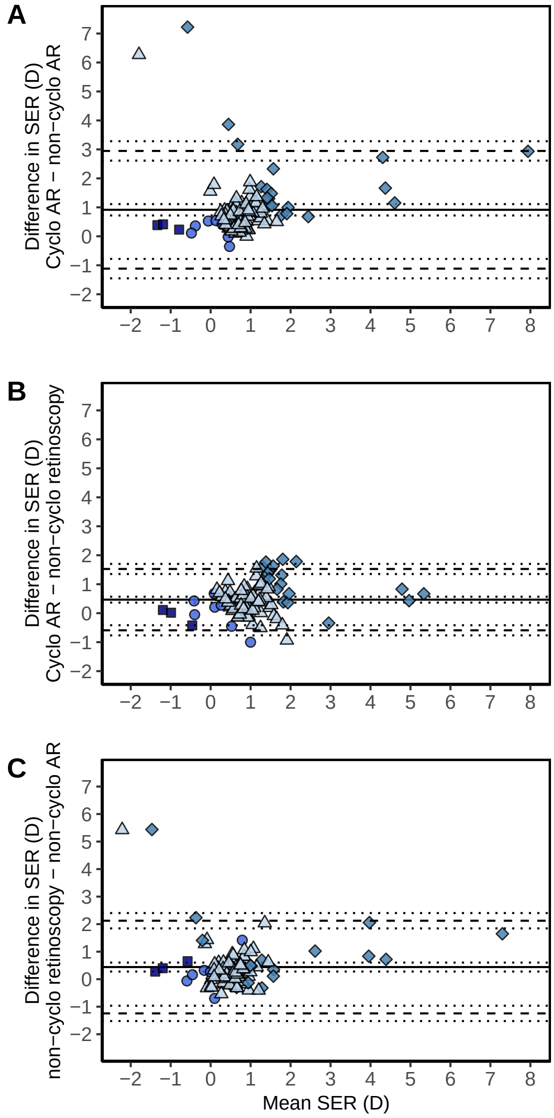

Figure 1: *Bland Altman plots showing agreement of SER between (A) cycloplegic autorefraction (cyclo AR) and non-cycloplegic autorefraction (non-cyclo AR), (B) cycloplegic autorefraction and non-cycloplegic retinoscopy, and (C) non-cycloplegic retinoscopy and non-cycloplegic autorefraction, for all participants. The difference of the two paired measurements is plotted against the mean, the mean represented by the x-axis, and the difference by the y-axis. The solid black line represents the mean of the differences, the dashed lines represent the upper and lower LoAs (95%), and the dotted lines represent 95% CI around the mean differences and the LoAs. Symbols: myopia = squares, emmetropia = circles, low hyperopia = triangles, moderate-to-high hyperopia = diamonds.*

Table 2 shows mean SER across the different refraction methods. The mean SER difference between the three refraction methods was largest for moderate-to-high hyperopia and small-

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Table 1: *Cycloplegic spherical equivalent refractive errors (SER) from autorefraction (right eye, n = 111) categorized by age and sex of both age groups and by type of refractive error.*

Age (years)	Group	n	Cycloplegic SER [D] Mean (SD)	Range	Cycloplegic refractive error type [%] Myopia	Emmetropia	Low hyperopia	Moderate-to-high hyperopia	Astigmatism
7–8	All	53	1.27 (0.75)	–0.98–3.03	3.8	1.9	77.4	17.0	11.3
	Female	26	1.43 (0.68)	–0.43–2.38	0.0	1.9	34.0	13.2	3.8
	Male	27	1.11 (0.79)	–0.98–3.03	3.8	0.0	43.4	3.8	7.5
10–11	All	58	1.40 (1.58)	–1.14–9.41	1.7	10.3	70.7	17.2	6.9
	Female	24	1.43 (1.30)	0.30–5.20	0.0	6.9	25.9	8.6	5.2
	Male	34	1.38 (1.87)	–1.14–9.41	1.7	3.5	44.8	8.6	1.7

Note: Myopia was defined as SER ≤ –0.50 D, emmetropia as –0.50 D < SER < +0.50 D, low hyperopia as +0.50 D ≤ SER < +2.00 D, moderate-to-high hyperopia as SER ≥ +2.00 D and astigmatism ≥ 0.75).

est for emmetropia and myopia (see Figure 2). The mixed model analysis revealed a significant difference in mean SER between the three refraction methods [$F(2, 215) = 47.1$, $p < 0.001$]. The interaction between refraction method and refractive group was significant [$F(4, 215) = 12.6$, $p < 0.001$]. Post hoc pairwise comparisons showed no difference in mean SER values between cycloplegic autorefraction and non-cycloplegic retinoscopy in myopia and emmetropia (difference in estimated marginal means ± SE: −0.022 ± 0.24, $p = 1.00$). However, there were differences for the low hyperopia (0.39 ± 0.08, $p < 0.001$) and the moderate-to-high hyperopia (1.06 ± 0.17, $p < 0.001$) groups, showing a significant underestimation of hyperopia with non-cycloplegic retinoscopy. Non-cycloplegic autorefraction gave a less positive SER than the other two methods for all refractive error groups, also diverging further with increasing hyperopia: the estimated mean difference ± SE between cycloplegic autorefraction and non-cycloplegic autorefraction was significant for low hyperopia (0.74 ± 0.08, $p < 0.001$) and moderate-to-high hyperopia (1.99 ± 0.17, $p < 0.001$), but not for emmetropia and myopia (0.26 ± 0.24, $p = 0.84$). Analysis showed that there was no significant difference between the two optometrists who performed the non-cycloplegic retinoscopy ($t(32) = 1.63$, $p = 0.11$)).

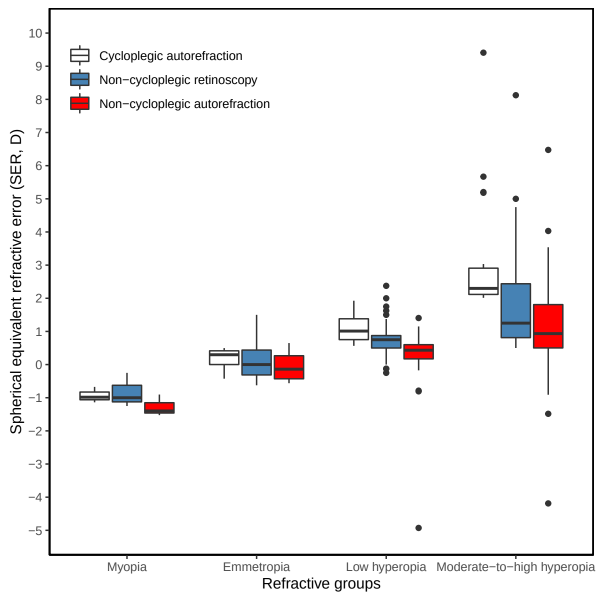

Figure 2: *Boxplot displaying SER data for the three different refraction methods (cycloplegic autorefraction, non-cycloplegic retinoscopy, and non-cycloplegic autorefraction, represented by white, blue, and red, respectively) classified by the four refractive groups: myopia, emmetropia, low hyperopia and moderate-to-high hyperopia. The 25–75 quantile (interquantile range, IQR) is represented by the height of the box, and the black line represents the median. The whiskers correspond to the range of the refractive measurement, except for the outliers (observations outside 1.5*IQR), which are represented by the black dots.*

Astigmatism ≥ 0.75 DC was found in ten children (9%), six (5.4%) of whom were aged 7–8 years. There was no statistically significant difference in mean cylinder power between cycloplegic and non-cycloplegic autorefraction ($t(109) = 0.49$, $p = 0.62$). There was a statistically significant difference in mean cylinder power between cycloplegic autorefraction and non-cycloplegic retinoscopy ($t(110) = -4.67$, $p < 0.001$, mean difference −0.15 DC). This was the case also between non-cycloplegic autorefraction and non-cycloplegic retinoscopy ($t(109) = -5.06$, $p < 0.001$, mean difference −0.16 DC).

Discussion

Here we show that there was no systematic relationship between non-cycloplegic and cycloplegic measures of refraction in a population with a high frequency of hyperopia. Even if cycloplegic autorefraction showed statistically and clinically significantly more positive SER than both non-cycloplegic autorefraction (0.92 D) and non-cycloplegic retinoscopy (0.47 D), it is not possible to predict which children would need cycloplegic refraction based on non-cycloplegic refraction alone. Importantly, there was an increase in the difference between cycloplegic and non-cycloplegic methods with more positive SER (see 2), which has major implications in a population where the frequency of hyperopia is high. The difference between cycloplegic and non-cycloplegic refraction was considerable. It should be emphasised that the results are part of a school vision testing protocol, and our findings are discussed in a screening context. These methods are regularly used as part of clinical examination where subjective refraction is the gold standard for prescribing. Omitting cycloplegic refraction may impact clinical judgment when prescribing glasses, and the associated risk is that children may be prescribed the wrong treatment (i.e., optical correction, myopia control, visual training, follow-up). In turn, this could affect academic performance and everyday life.

The difference in results between cycloplegic and non-cycloplegic methods was expected as a few studies have already demonstrated that the administration of cycloplegic drugs prior to measuring refraction, independent of method, results in a more hyperopic refraction (Choong et al., 2006; Doherty et al., 2019; Fotouhi et al., 2012; Hashemi et al., 2016; Kirschen & Isenberg, 2014). L. B. Wilson et al. (2020) reported refraction to be up to 2.0 D more hyperopic for cycloplegic than for non-cycloplegic autorefraction in children. More specifically, our results regarding the comparison of cycloplegic and non-cycloplegic autorefraction are comparable with the results from an Australian study in children aged 6 years and 12 years (mean SER difference 1.18 D and 0.84 D, respectively) (Fotedar et al., 2007). Studies in countries with a higher prevalence of myopia have reported smaller differences, including a study in Chinese children aged 4–15 years (0.63 D) (Sankaridurg et al., 2017), and

Table 2: *Measurements of spherical equivalent refractive error (SER) across different refraction methods.*

Age (years)	*n*	Cycloplegic Autorefraction SER [D] Mean (*SD*)	Range	Non-cycloplegic Autorefraction SER [D] Mean (*SD*)	Range	Non-cycloplegic Retinoscopy SER [D] Mean (*SD*)	Range
All	111	1.34 (1.25)	−1.14–9.41	0.42 (1.17)	−4.93–6.48	0.87 (1.12)	−1.25–8.13
7–8	53	1.27 (0.75)	−0.98–3.03	0.28 (0.86)	−4.19–1.52	0.73 (0.59)	−1.00–2.38
10–11	58	1.40 (1.58)	−1.14–9.41	0.54 (1.39)	−4.93–6.48	1.00 (1.44)	−1.25–8.13

Note: Measurement of non-cycloplegic autorefraction is missing for one participant.

Iranian children aged 5–10 years (0.71 D) (Fotouhi et al., 2012). However, these studies are from populations with a higher frequency of myopic children than that reported in Scandinavian countries (Demir et al., 2021; Hagen et al., 2020; Sandfeld et al., 2018). Our results for differences between cycloplegic autorefraction and non-cycloplegic retinoscopy were in line with a study comparing cycloplegic and non-cycloplegic retinoscopy in a similar age group (6–13 years) of Northern-Irish children with mean sphere differences of 0.59 D (Doherty et al., 2019). A study of Chinese children (3–5.5 years) in Hong Kong found larger differences, but the participants were younger compared to our study (Chan & Edwards, 1994).

Non-cycloplegic autorefraction deviated from cycloplegic autorefraction across all groups of refractive errors. While non-cycloplegic retinoscopy was more accurate for myopia and emmetropia, hyperopia was underestimated, and particularly moderate-to-high hyperopia. This is in line with other studies that found a larger deviation in higher hyperopia with non-cycloplegic than cycloplegic refraction (Doherty et al., 2019; Morgan et al., 2015; Sankaridurg et al., 2017). However, there were few participants in the myopia and emmetropia groups. Comparison of results across studies was constrained by the variety of experimental protocols in different studies comparing non-cycloplegic and cycloplegic results, including different age groups, populations, types of autorefractors, and other experimental procedures. Regardless of these limitations, the weight of evidence suggests that non-cycloplegic autorefraction and retinoscopy tend to underestimate hyperopia, and overestimate myopia (Choong et al., 2006; Doherty et al., 2019; Hashemi et al., 2016; Kirschen & Isenberg, 2014). The LoAs were wide and considerably wider for the difference between cycloplegic and non-cycloplegic autorefraction (−1.12 to 2.94 D) than between cycloplegic autorefraction and non-cycloplegic retinoscopy (−0.59 to 1.53 D). These results highlight the importance of using cycloplegia for every child to provide the correct refractive prescription, as has been stated in by other researchers (Fotedar et al., 2007; Fotouhi et al., 2012; Sankaridurg et al., 2017).

Omitting cycloplegic refraction implies a risk of undercorrecting hyperopic children, and even prescribing myopic correction in severe cases. The consequence can be that a hyperopic child is prescribed with a lower prescription than required, with the risk of not experiencing the full benefit of their correct prescription, not prescribed prescription at all, or given glasses for reading and part-time use when they, both in developmental and educational terms, would have benefitted from constant use (Bruce et al., 2018; Ma et al., 2014). A hyperopic refractive error may be disguised as an accommodative or binocular disorder, and the child may be provided with unnecessary near vision addition lenses or orthoptic training. A child wrongly classified as myopic may be at risk of receiving unnecessary treatments, e.g., given minus prescription or even myopia control. A wrong correction can lead to asthenopia such as headache, eyestrain, double vision, or blur, especially when the child is performing cognitively demanding tasks (Kulp et al., 2016; Neitzel et al., 2021; Williams et al., 2005). Wrong or unnecessary treatments impose increased costs, expenses, and time consumption, and may be detrimental for the child in terms of educational attainment.

Strengths and limitations

A strength in this study is that the participants included were unselected children from two school-years at a representative school in the municipality. A limitation may be that the effect of cycloplegia was not objectively assessed. However, measurements were performed 30–40 minutes after instillation of cycloplegic drops. Further, a high proportion of children have light iris pigmentation in Norway, like in other Northern European countries, and previous research has suggested that there is a significant effect of cycloplegia in persons with light irises as early as 10 minutes after the instillation of cyclopentolate 1% (Manny et al., 1993). Still, if full cycloplegic refraction was not obtained in every child, it is likely that the cycloplegic refraction would have been further skewed towards hyperopia, strengthening our findings.

Conclusion

The mean differences and the 95% limits of agreement between non-cycloplegic retinoscopy and autorefraction were too wide to ensure correct refractive error diagnosis. The risk of misdiagnosis increases with the degree of hyperopia. For hyperopes, in particular, the results show that there are unforeseen between-individual differences in the effect of cycloplegia, rendering the non-cycloplegic measures unreliable. This emphasises the importance of cycloplegic refraction as the preferred method when refracting children.

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Ikke-cycloplegisk refraksion kan ikke erstatte cycloplegisk refraksjon ved screening for refraktive feil hos barn

Sammendrag

Hensikten var å vurdere forskjellene i refraktive feil (sfærisk ekvivalent refraksjon, SER) målt med mye brukte screeningsmetoder: cycloplegisk autorefraksjon (1% cyclopentolat), ikke-cycloplegisk autorefraksjon og ikke-cycloplegisk retinoskopi i en populasjon med høy forekomst av hyperopi. Refraktiv feil ble målt med de tre metodene hos 111 barn i alderen 7–8 og 10–11 år. Bland-Altman-analyse ble brukt til å vurdere forskjellene i gjennomsnitt (*MD*) og 95% samsvarsgrenser (LoA) mellom cycloplegisk autorefraksjon og de to ikke-cycloplegiske metodene. En blandet effektmodell ble brukt til å undersøke forskjellene mellom metodene for de ulike refraktive gruppene. Cycloplegisk autorefraksjon ga en signifikant mer positiv SER enn både ikke-cycloplegisk retinoskopi (*MD* = 0,47 D, LoA = -0,59–1,53 D) og ikke-cycloplegisk autorefraksjon (*MD* = 0,92 D, LoA -1,12–2,95 D). De gjennomsnittlige forskjellene i SER økte med økende grad av hyperopi [$F(4, 215) = 12{,}6$, $p < 0{,}001$], både ved sammenligning av cycloplegisk refraksjon med ikke-cycloplegisk retinoskopi og med ikke-cycloplegisk autorefraksjon.

Ikke-cycloplegisk retinoskopi og autorefraksjon gir betydelig mindre positiv SER enn cycloplegisk autorefraksjon. De brede konfidensintervallene for den gjennomsnittlige forskjellen og samsvarsgrensene er klinisk uakseptable, og metodene kan ikke brukes om hverandre. Følgelig vil refraksjon uten cycloplegi forårsake feildiagnostisering hos noen barn. Selv om ikke-cycloplegisk retinoskopi gir smalere samsvarsgrenser, elimineres ikke risikoen for feildiagnostisering ved å ha erfaring med å retinoskopere. Vi viser at det er viktig å bruke cycloplegi ved refraksjon av barn, spesielt i en populasjon med høy forekomst av hyperopi, for å sikre at ingen hyperope forblir uoppdaget.

Nøkkelord: Barn, cycloplegisk (våt) autorefraksjon, ikke-cycloplegisk (tørr) retinoskopi, cyclopentolate

La refrazione non cicloplegica non puo' sostituirsi alla refrazione cicloplegica nel rilevamento degli errori refrattivi nei bambini

Riassunto

Lo scopo di questo studio e' stato quello di verificare le differenze nell'errore come equivalente sferico (SER) considerando metodi comuni di screening; autorefrazione con cicloplegico (1% ciclopentolato), autorefrazione senza cicloplegico e retinoscopia senza cicloplegico in una popolazione con alta prevalenza di ipermetropia.

L'errore refrattivo e' stato misurato con i 3 metodi in 111 bambini di eta' tra i 7 e gli 8 anni e tra i 10 e gli 11 anni. L'analisi Bland-Altmas e' stata considerata per verificare la media delle differenze (*MD*) e il limite al 95% di accordo (LoA) tra la autorefrazione con cicloplegico e i due metodi senza cicloplegico. Un modello ad effetto misto e' stato considerato per ricercare le differenze tra i metodi nei gruppi refrattivi.

L'autorefrazione con cicloplegico ha riportato un valore piu positivo di SER rispetto ad entrambe retinoscopia senza cicloplegico (*MD* = 0.47 D, LoA = -0.59–1.53 D) ed autorefrazione senza cicloplegico (*MD* = 0.92 D, LoA of -1.12–2.95 D). La differenza media del SER e' aumentata con l'aumentare del grado di ipermetropia [$F(4, 215) = 12.6$, $p < 0.001$], comparando entrambe le tecniche con refrazione cicloplegica, retinoscopia senza cicloplegico e autorefrazione senza cicloplegico.

La retinoscopia senza cicloplegico e l'autorefrattometria risultano in valori significativamente meno positivi di SER rispetto all'autorefrazione con cicloplegico. Gli ampi intervalli di confidenza per la media e i limiti di accordo sono clinicamente inaccetabili e tali metodi non possono essere intercambiabili. Di conseguenza, la refrazione senza cicloplegico potrebbe causare diagnosi errate in alcuni bambini.

Anche se la retinoscopia senza cicloplegico rilsuta in valori piu' contenuti nei limiti di accordo, il rischio di errata diagnosi non e' eliminato dal fatto di eseguire la retinoscopia con esperienza. Abbiamo dimostrato che e' essenziale l'uso di cicloplegico per la refrazione in bambini, particolarmente in una popolazione con elevata prevalenza di ipermetropia, e per assicurare che l'ipermetropia non rimanga non rilevata.

Parole chiave: Bambini, autorefrazione con cicloplegico, refrazione senza cicloplegico, retinoscopia senza cicoplegico, ciclopentolato