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ORIGINAL ARTICLE

Comparison of Habitual Visual Acuity and Stereoacuity between Children Attending Kemas and Urban Private Preschools

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ABSTRAK

Penilaian status visual kanak-kanak prasekolah adalah penting kerana ia adalah salah satu faktor yang menentukan ketersediaan mereka untuk bersekolah. Walau bagaimanapun, tidak semua kanak-kanak prasekolah mendapat peluang untuk mengikuti program saringan penglihatan. Dalam kajian ini, akuiti visual jauh dan dekat serta tahap stereoakuiti diukur di kalangan kanak-kanak berumur enam tahun (n=385). Parameter tersebut kemudiannya dibandingkan di antara kanak-kanak prasekolah swasta bandar dan prasekolah KEMAS daripada keluarga berpendapatan rendah di luar bandar. Tujuh peratus kanak-kanak prasekolah KEMAS adalah gagal dalam ujian saringan penglihatan jauh berbanding dengan 6% kanak-kanak prasekolah swasta. Untuk ujian penglihatan dekat, kadar kegagalan adalah masing-masing 8.7% dan 4.9% bagi kanak-kanak prasekolah swasta dan KEMAS masing-masing. Untuk ujian stereoakuiti, seramai 3.3% kanak-kanak prasekolah swasta dan 2.5% kanak-kanak prasekolah KEMAS dikategorikan sebagai lemah stereopsis. Semua perbezaan tersebut adalah tidak signifikan secara statistik (semua p>0.05). Peratusan kanak-kanak yang gagal ujian saringan penglihatan adalah serupa untuk kedua-dua jenis prasekolah. Oleh itu, program saringan penglihatan perlu dijalankan di semua jenis prasekolah untuk memastikan sebarang masalah penglihatan dapat dikesan, didiagnos, dirawat dan dicegah.

Kata kunci: akuiti visual, kanak-kanak prasekolah, persepsi kedalaman, saringan penglihatan

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ABSTRACT

The assessment of a preschooler's visual status is important as it forms part of the measure to assess the child's school readiness. However, not all children attending preschools have equal opportunity to undergo vision screening programmes. In this study, we measured presenting habitual near and distance visual acuity and stereoacuity in 6-year-old children (n=385). These parameters were measured in and compared between preschoolers attending urban, privately-run kindergartens and those attending KEMAS preschools, which were typically from suburban and rural areas with families of very low income. Seven percent of KEMAS preschoolers failed the distance visual acuity test while the failure rate for private preschoolers was 6.0%. For near visual acuity, a higher percentage of private preschoolers failed the test (8.7%) than KEMAS preschoolers (4.9%). A slightly higher percentage of private preschoolers had weak stereopsis (3.3%) compared to KEMAS preschoolers (2.5%). However, the differences found between the two preschooler groups were not statistically significant (all $p>0.05$). The proportion of children who failed each of the screening criteria for distance vision, near vision, and stereopsis was similar between KEMAS and private preschools. Therefore, an universally inclusive vision screening programme should be conducted for all preschool types to detect, diagnose, treat, and potentially prevent any visual impairment.

Keywords: depth perception, preschool children, vision screening, visual acuity

INTRODUCTION

It has been reported that 10% of Malaysia Year 1 pupils (i.e., 7-year-olds) do not achieve basic mastery of numeracy skills (Government Transformation Programme Annual Report 2013), that is, these pupils are not ready when they start formal schooling. One of the factors that may affect school readiness is a child's visual status and development of normal vision (McConachie 2018; Rajput et al. 2018). Optimal school performance is influenced by a child's visual status (Walline & Johnson Carder 2012; Garzia et al. 2008), as there is an association between academic performance and both visual acuity and refractive error in children (Hopkins et al. 2020). Similarly, a child's neurodevelopment, literacy, and quality of life can be impacted by reduced visual acuity (Rosenberg et al. 1996; Bruce et al. 2016; Mervis et al. 2002).

Hence, visual screening programmes are regularly conducted to detect any vision abnormalities in children of various age groups. Currently in Malaysia, vision screening is conducted under the care of the Ministry of Health within the health screening programmes (Ismail et al. 2002). However, it only covers the government schools and not for private

independent schools. Only children aged 7, 12 and 15 years are involved in the health screening. Only recently, vision screening programmes have been introduced for preschool children. However, they are limited to 6-year-olds attending specific government-run preschools under the care of the Ministry of Education (MOE). In reality, a considerable number of children in the country attend various types of preschool (either privately-run or those under government agencies other than MOE and they may do so from the age of four. This unique situation may lead to undetected vision impairment thus a delay in necessary interventions that should be taken especially in cases of common visual impairment in children such as amblyopia.

In a vision screening programme, distance visual acuity is regularly measured as it has high sensitivity and specificity for detecting myopia (O'Donoghue et al. 2012). However, previous reports on visual screening programmes conducted in Malaysia did not assess their participants' near visual acuity (Premsenthil et al. 2013; Omar et al. 2019; Ain et al. 2009; Nurul et al. 2012; Farhana et al. 2012; Hussin et al. 2009) and stereoacuity (Farhana et al. 2012; Omar et al. 2019; Nurul et al. 2012; Hussin et al. 2009; Ain et al. 2009). Near visual acuity test is suitable for the detection of amblyopia risk factors, high myopia and high astigmatism in children (Huang et al. 2014; Jin et al. 2015). Indeed, the combination of distance visual acuity and near visual acuity tests was reported to be useful as indicators for significant refractive errors, comparable to the findings obtained with cycloplegic autorefraction (Jin et al. 2015). Ideally, the assessment of near visual acuity should be part of a vision screening programme as children are also engaged in continuous near fixation tasks for up to 30 minutes at a time (Narayanasamy et al. 2016).

Good stereoacuity, together with other near visual functions, is significantly correlated to school children's academic performance (Kulp & Schmidt 2002) and motor skills tasks (O'Connor et al. 2010). Poor stereopsis has a negative impact on the neurodevelopmental performance, which may lead to reading difficulty in the preschool year and poor intelligence in subsequent first-grade children (Ponsonby et al. 2013; Richardson et al. 2005). If an intervention for stereoacuity disorder is not provided within a child's critical period, the loss of stereopsis may become permanent (Wright et al. 1994). In amblyopic children, stereoacuity was found to be significantly correlated with visual acuity (Lee & Isenberg 2003). Therefore, it is important to screen stereoacuity disorder and provide timely interventions for young children with poor stereoacuity.

In this study, we measured presenting habitual visual acuity, both distance and near, and stereoacuity in a sample of 6-year-old preschool children. The assessment of these visual functions is of importance as it forms part of the measure to assess a child's school readiness. Participants were preschoolers attending privately-run kindergartens and KEMAS preschools, which are under the care of the Ministry

of Rural Development. Children who enrolled in KEMAS preschools were from suburban, rural, and remote areas with families of very low income (Mustafa & Azman 2013), relative to those attending private preschools that charge higher fees and are located in more urbanized areas. Therefore, we hypothesized that a higher number of KEMAS preschoolers would have worse habitual vision status relative to those attending private preschools.

MATERIALS AND METHODS

The study was conducted at nine KEMAS preschools and five privately run preschools within the Klang Valley area, specifically, Ampang, Gombak, and Sepang. Participants were preschool children aged between 5- 6 years, specifically, those who would be attending Year 1 of primary school in the year following data collection.

Since the sample consisted of children attending preschool during data collection, the sample size was calculated based on the number of children born in Selangor and Kuala Lumpur in 2014 (134,928) (Jabatan Perangkaan Malaysia 2015). Thus, from this known population size, a sample size of 383 participants would be within a margin of error of 5% at a confidence level of 95% (Krejcie & Morgan 1970).

A list of KEMAS preschools located in Selangor and Kuala Lumpur was obtained from the Selangor and Kuala Lumpur Community Development Departments (Jabatan Kemajuan Masyarakat, KEMAS). A list of private preschools in Kuala Lumpur was obtained via Internet search engines. All preschools were selected for this study using simple random sampling. The selection of private preschools was subject to permission by the headteachers.

Within the selected preschools, vision screening was conducted on all enrolled children subject to consent. Written informed consent was obtained from the children's parents or legal guardians prior to any data collection. Assent was also sought from the participants. Those who did not assent to, and/or whose parents did not consent, were excluded from the study. Exclusion criteria were: any child with a self-reported history of physical, pathological, and/or cognitive disabilities. The conduct of this study followed the tenets of the Declaration of Helsinki, and ethical approvals were obtained from Universiti Kebangsaan Malaysia's Research Ethics Committee (UKM/PPI/800-1/1/5/JEP-2019-476) and the Ministry of Rural Development, Malaysia (BPAK620-02/01/01 Jld 15).

Habitual distance and near visual acuity was measured for each eye using the LEA Symbols® 15-Line Pediatric Eye Chart and the LEA Symbols® Near Vision Card (Good-Lite Co, Elgin, IL), respectively. Visual acuity was scored for each correctly recognized symbol and recorded in units of the logarithm of the Minimum Angle of Resolution (logMAR). Fail criteria for habitual distance visual acuity was 0.3 logMAR and worse (Ain et al. 2009) in either eye or in both eyes. Fail criteria for habitual near visual acuity as logMAR 0.4 (N8) and worse in either eye or in both eyes. Stereopsis was assessed

using the Frisby Stereotest (Frisby Stereotests, Fulwood, United Kingdom). A stereoacuity score of 85 arcsec or better classified was as good (Frisby 2015; Anketell et al. 2013). Stereoacuity between 85 and 300 arcsec was classified as moderate, while a score of 300 was classified as weak (Frisby 2015). All tests were conducted with the participants wearing their existing optical prescription, that is, with their habitual vision, under sufficient room lighting. Participants who met any of the fail criteria were referred for further vision assessment to the Optometry Clinic, Faculty of Health Sciences, Universiti Kebangsaan Malaysia. All tests were conducted by an Optometry postgraduate student, assisted by five final year undergraduate students of the Bachelor of Optometry programme. All conducts were under the advice of one of the authors (MIH).

Differences in the distance and near visual acuity results between right and left eyes and preschool types were analyzed using the Mann-Whitney test. Stereoacuity performance was categorized as either good, moderate, or weak. Differences in the failure rate for each test between preschool types (categorical data) were analyzed using chi-square tests ($\chi 2$). The correlations between visual acuity and stereoacuity were assessed using Spearman correlation analyses. All reported p values are two-sided and $p<0.05$ was considered statistically significant. The Statistical Package for Social Sciences (SPSS) version 22 software was used to analyse all data.

RESULTS

In total, 395 preschoolers with a mean age of 71.75 $\pm$ 5.64 months (5.99 $\pm$ 0.50 years) participated in this cross-sectional study. The sample size was within a margin of error of 5% at a confidence level of 95% (Krejcie & Morgan 1970). Males comprised 54.2% of the participants. The largest ethnic group was Malay (82.5%) and a majority of the participants were enrolled with KEMAS preschools (61.8%). The demographic characteristics of the participants are summarised in Table 1.

Figure 1 shows the frequency distribution of distance visual acuity (DVA) for the right and left eyes. The

Table 1: Study population demographics

Demographic characteristics		N (%)
Gender	Male	214 (54.2%)
	Female	181 (45.8%)
Ethnicity	Malay	326 (82.5%)
	Chinese	20 (5.1%)
	Indian	4 (1.0%)
	Orang Asli (indigenous)	17 (4.3%)
	Others	28 (7.09%)
Preschool type	KEMAS (government-run)	244 (61.8%)
	Private preschools	151 (38.2%)

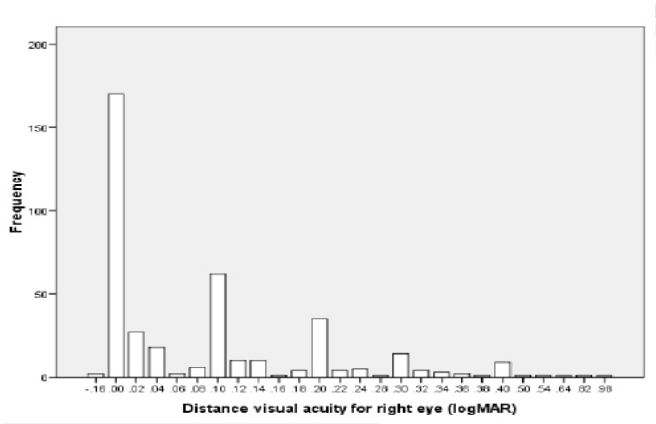

Figure 1: Frequency distribution of distance visual acuity, in logMAR, for right (top panel) and left (bottom panel) eyes

mean DVA for the right eye and left eye were similar, that is, 0.09 ± 0.13 logMAR for each eye. Mann-Whitney analyses revealed that the difference in DVA for right eye and left eye between KEMAS and private preschoolers were not statistically significant (right eye, z=-1.28, p=0.20; left eye, z=1.59, p=0.11). However, 6.8% of participants had an interocular difference of DVA of 0.2 logMAR. In total, 6.6% of the total number of participants had habitual DVA of 0.3 logMAR or worse in each eye. Within the KEMAS preschoolers group, 7.0% failed the DVA test while the failure rate for private preschoolers was 6.0% but this difference was not statistically significant (χ^2=0.15, p=0.70).

Figure 2 shows the frequency distribution for the right and left eye for near visual acuity (NCVA). The mean habitual NVA was also similar for each eye (0.22 ± 0.06 logMAR). The difference in NVA for the right eye and left eye between KEMAS and private

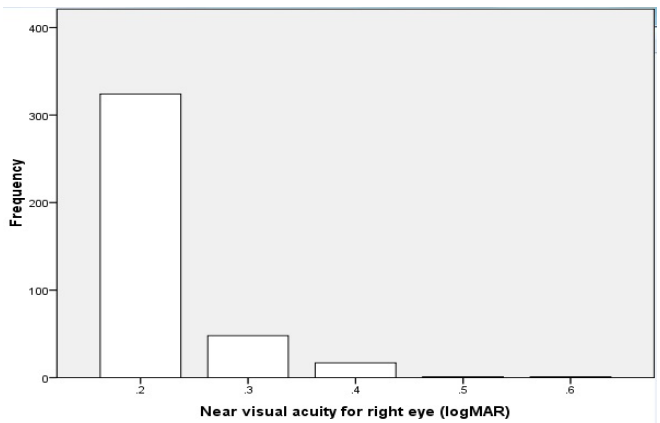

Figure 2: Frequency distribution of near visual acuity, in logMAR, for the right (top panel)and left (bottom panel)eyes

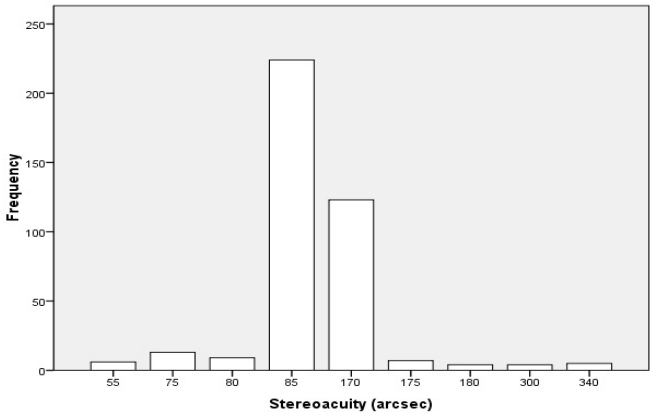

Figure 3: Distribution of stereoacuity based on stereoacuity scores (top panel) and categories of stereopsis (bottom panel)

preschoolers were not statistically significant (Mann-Whitney, right eye, z=-1.78, p=0.08; left eye, z=1.59, p= 0.11). In total, 6.4% of participants had habitual NVA of 0.4 logMAR or worse in each eye. For NVA assessment, a higher percentage of private preschoolers failed the test (8.7%) than KEMAS preschoolers (4.9%). This difference was not statistically significant (χ^2 = 2.22, p=0.14).

Figure 3 shows the frequency distribution for stereoacuity measured with the Frisby stereotest. The median stereoacuity was 85 arcsec (interquartile range: 85-170). Overall, 64.3% had stereoacuity of 85 arcsec or better, 32.9% were moderate and 2.8% had weak stereopsis (≥300 arcsec). A slightly higher percentage of private preschoolers had weak stereopsis (3.3%) compared to KEMAS preschoolers (2.5%) but this difference was not statistically significant (χ^2=0.35, p=0.84).

There was a very weak correlation between DVA and stereoacuity (Spearman's rho=0.15, p=0.03). The correlation between NVA and stereoacuity was also very weak (Spearman's rho=0.12, p=0.02). That is, reduced distance and near acuity were weakly associated with a reduction in stereoacuity. Table 2 summarises the findings for DVA, NVA, and stereoacuity based on preschool type.

DISCUSSION

One of the major causes of preventable blindness is uncorrected refractive error (Flaxman et al. 2017). Hence, it should be detected early especially in very young children, to prevent a reduction in the quality of their eyesight. To reiterate, screening programmes offered at preschool level in the country are limited to 6-year-olds attending specific government-run preschools under the Ministry of Education (MOE). The current protocol would have missed those with reduced visual acuity and stereopsis levels who are enrolled in non-MOE preschools (Ismail et al. 2002). KEMAS preschools are under the governance of the

Table 2: Distribution of preschoolers who failed the screening assessment criteria based on preschool type

Criteria		KEMAS pre-schoolers	Private pre-schoolers	Total	p-value
Distance visual acuity ≥0.3 logMAR in each eye		17 (7.0%)	9 (6.0%)	26 (6.6%)	0.70
Near visual acuity ≥0.4 logMAR in each eye		12 (4.9%)	13 (8.7%)	25 (6.4%)	0.14
Stereoacuity	85 arcsec or better	156 (63.9%)	98 (64.9%)	254 (64.3%)	0.84
	85<stereoacuity<300 arcsec	82 (33.6%)	48 (31.8%)	130 (32.9%)	
	300 arcsec or worse	6 (2.5%)	5 (3.3%)	11 (2.8%)	

Ministry of Rural Affairs. Its targeted population is children from suburban, rural, and remote areas with families of very low income (Mustafa & Azman 2013). Whereas, enrolment in private preschools may cost up to MYR400 (USD50) in monthly fees. As the reported Malaysian median monthly household income for urban and rural areas is Malaysian Ringgit (RM) 5860.00 and for RM3471.00, respectively (Department of Statistics Malaysia 2017), the choice made by parents for non-MOE preschool enrolment may be partly influenced by the family's socio-economic background.

This study demonstrates that regardless of a child's preschool type, there is a similar proportion of preschoolers who failed each of the screening criteria for distance vision, near vision, and stereopsis. This would have an impact on the learning experience of these children, especially if no intervention was provided by the time they enrolled in primary schools. It has been published recently that for a Malaysian lower primary classroom, its environment demands for DVA was 0.11 $\pm$ 0.26 logMAR and for NVA was 0.24 $\pm$ 0.10 logMAR (Azizan et al. 2019). Therefore, 6% of our participants who failed our DVA and NVA criteria may not be able to learn as well as their better-sighted peers do if their vision remains uncorrected. Although a young child has the ability to self-report blurred distance vision reliably (Hu et al. 2013), their ability to report monocular blur, suppression, or reduced depth perception i.e. stereopsis is likely to be less reliable. The results in our study echoed those reported earlier in the country. Omar et al. (2019) reported a 5.4% prevalence of myopia among rural Orang Asli school children, while Premsenthil et al (2013) reported that 4.25% of their 4 to 6-years-old individuals in urban Kuching had habitual acuity of 6/12 and 1% did not pass the stereoacuity test. Another study that was conducted on primary school children in suburban Kota Bharu also reported an uncorrected refractive error prevalence of 6.6% (Hashim et al. 2008) which is very similar to what we found based on acuity measurement. The findings of our study were also similar to those reported outside of Malaysia. For example, in Singapore, the reported prevalence of myopia for 6-year-olds

was 6.4% (Dirani et. al 2010) while in Shanghai, 9.2% of 6-year-olds had an uncorrected refractive error (Ma et. al 2016).

It is also important to note that only 64.3% of our participants had stereoacuity of 85 arcsec or better, with a median of 85 arcsec. Premsenthil et al. (2013) reported that 1% of their 4 to 6-years did not pass the stereoacuity test. Anketell et al. (2013) reported that 95% of their primary school participants had stereoacuity of 85 arcsec or better and with a much lower median (25 arcsec) for a 6 to 7-years group. Bohr & Read (2013), also using Frisby stereotest, reported median stereoacuity of 25 arcsec for their 5- to 10-year-olds. Higher (worse) median stereoacuity for the population of this study could be partly due to 6.8% of our participants had an interocular difference in VA of 0.2 logMAR. Indeed, a large VA difference between the two eyes would have resulted in reduced stereopsis (Lam et al. 1996). Meanwhile, previous studies used it as one of the exclusion criteria (Bohr & Read 2013; Anketell et al. 2013) which would have led to the lower (better) median stereoacuity. Nevertheless, this finding points to an urgent need to screen young children for any abnormalities in their visual function.

In this study, we found that the correlations between visual acuity (VA) (distance and near) and stereopsis to be very weak. This appears to be in contrast with a previous longitudinal study on amblyopic children who underwent occlusion therapy, which showed an improvement in VA was significantly correlated with an improvement in stereoacuity (Lee & Isenberg 2003). We might have found a stronger correlation between visual acuity and stereopsis had our participants been diagnosed with amblyopia. It was argued that for a normally sighted observer, although stereoacuity decreases about the same ratio as does VA, but VA can be normal even without any stereopsis or VA can be poor with good stereoacuity (Burian 1951). Therefore, a universally inclusive vision screening programme should be conducted in all preschool types annually to detect, diagnose, treat, and potentially prevent any visual impairment. It should also be part of a young child's school readiness assessment so their intellectual development, maturity, and performance are not hampered when formal primary schooling commences.

The strength of this study was the use of standard and scientifically valid acuity tests based on logMAR scoring to quantify vision. The use of these tests allowed letter-by-letter scoring which was more accurate and analytically convenient, compared to other tests such as the Snellen chart or the N-notation reading chart (Bailey & Lovie-Kitchin (2013). This study also showed that simple vision tests should be conducted on all young children regardless of their background, so that intervention can be provided to those who need it.

In this study, we did not measure the children's refractive error. Those who failed the acuity screening tests already had a habitually blurred vision which could be due to uncorrected myopia and/or astigmatism. We might

have missed children with significant uncorrected latent hyperopia, who might not have blur vision due to their high accommodation. Some of the children might also have low myopia which would result in blur vision, but not severe enough to fail the screening criteria. In a future study, cycloplegic refraction should be performed on the preschoolers, which would enable the observation on the distribution of refractive error and the prevalence of visual impairment based on preschool types.

CONCLUSION

In this study, presenting habitual near and distance visual acuity and stereoacuity in 6-year-old children attending KEMAS and private preschools were measured and compared. Six percent and 3% of children failed the habitual acuity and stereoacuity screening criteria. The failure rate was similar between KEMAS and private preschools. It is crucial for all preschool children to undergo an eye examination to detect any presenting blur vision and reduced stereopsis.

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