

Evaluation of a screening software for amblyopia

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Abstract

• **AIM:** To investigate the efficacy of a novel screening software for amblyopia.

• **METHODS:** Totally 324 preschoolers aged 3-6y old from outpatient department participated in the study in 2017. They were assessed for amblyopia by their parents, using the screening software and were reevaluated by ophthalmologists with professional eye tests. Sensitivity, specificity of the screening software was validated by comparing the results from the screening software and those from the professional tests.

• **RESULTS:** All 324 children (176 males and 148 females) completed all the procedures. Four amblyopes were found by professional tests. And 3 of them were detected by the screening software. The sensitivity, specificity was 75.0%, 90.0%, respectively. Professional tests cost an average of US\$ 607.5/case of amblyopia detected, whereas the cost was near US\$ 0/case for the screening software, except the cost of software development.

• **CONCLUSION:** The results from this pilot study indicate that the screening software for amblyopia is a simple, and highly effective, which offers a new option of amblyopia screening for developing countries.

• **KEYWORDS:** preschoolers; amblyopia, screening software

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INTRODUCTION

Amblyopia is the main cause of visual impairment in children and affects approximately 2%-4% population worldwide^[1]. The disorder causes monocular visual deficits, including reduced acuity, a loss of depth perception and contrast sensitivity, but with the absence of observable ocular pathology. The pathogenesis of amblyopia is generally accepted to be related to abnormal vision experience during the critical developmental period of vision (*e.g.* from natal to 8y), such as strabismus, severe refractive error, anisometropia and deprivation of form sense (*e.g.* ptosis)^[2-3].

Since usually, this disorder does not cause discomfort and children tends to lack adequate eloquence, amblyopia is frequently found until late into the childhood and even early youngster hood. Consequently, undetected and untreated amblyopia can interfere with a child's ability to learn in school and participation in sports and even with an adult's ability to do their job or to drive safely. On the other hand, amblyopia is a reversible disease that can be cured in a relatively simple and efficient method if being treated in their early life. Otherwise, the effectiveness of the treatment becomes significantly less efficient with time^[4]. Thus, the critical issue to manage this disorder is therefore to detect amblyopia as early as possible.

Screening could detect preschool children with amblyopia at a critical period of visual development and lead to treatments which could improve vision. Being aware of the significance, lots of screening systems are introduced in different countries. For example, in Korea, a nationwide school-based screening system had been initiated since 1997, while a stepwise screening system, beginning with the home-based vision screening, retesting in the public healthcare centers and then referring to comprehensive professional tests in eye clinics, were recently advocated^[5]. In Germany, screening in kindergarten by orthoptists, testing visual acuity, heterophoria, eye motility and head posture, was the dominant system^[6-7].

Obviously, these amblyopia screening systems are not applicable in developing countries, like China, due to the prematurity of the public health system, inadequate medical resources and the ignorance of relevant knowledge of this disorder by average people. Consequently, there is an urgent need to establish a self-test strategy to tackle this issue. In our previous study^[8], we established a home-based amblyopia screening package and it showed significant validity and cost-effectiveness in Guangzhou, China. With the development of

internet, we transformed it into a software version in order to decrease cost. It may be especially applicable in developing countries with large populations.

SUBJECTS AND METHODS

The screening software was derived from amblyopia screening package^[8], which was composed of 2 core parts, a set of separate visual acuity charts and a questionnaire composed of 6 questions about common amblyopic risk factors (Figure 1). Internet technology was used to transform the 2 main parts into digital versions and the screening software was built. Figure 2 showed the first page of the software.

Totally 324 children (176 males and 148 females) were recruited and their parents were provided identification numbers and passwords of the screening software for free in outpatient department. Following the instruction of the screening software, parents would help children finishing vision test and fill the final questionnaire online. Finally, the software would make a diagnosis of amblyopia or not.

All preschool children were reevaluated by the ophthalmologist. Examination of refraction state: Cycloplegia was induced with two drops of 1% cyclopentolate instilled 5min apart. Sixty minutes later, refractive error was determined by an auto-refractor(Topcon AR 8800, Tokyo, Japan), which was rechecked by retinoscopy; 48h later, the best corrected visual acuity by standard logarithmic visual acuity chart with tumbling-E optotypes (Precision Vision, La Salle, IL) under bright light at a distance of 3 m would be measured. Examination of eyes: With the professional methods and instruments of the ophthalmology such as slit lamp microscope, the direct ophthalmoscope and focus pocket lamp etc, the targets were conducted to undertake the inspection of objective ocular region, especially the cover-test at far and near fixation.

Taking into account all of the information collected, a final diagnosis of amblyopia was determined by the ophthalmologist, using the same criteria adapted from our previous study^[8].

Ethical Issues and Statistics The study adhered to the tenets of the Declaration of Helsinki. The Ethics Committee of Ethics Committee of Zhongshan Ophthalmic Center approved the study. The purpose and methods of the study, including rare but reversible complications of cyclopentolate eyedrops, were explained to the parents before examinations and informed consents were signed.

The data were expressed as mean ± SEM. Results from the amblyopia screening software were then compared with those determined by professional tests, and the sensitivity and specificity of the screening software were calculated. Pearson χ^2 test was performed to analyzed the difference with SPSS19.0 software.

THE LAZY EYE SCREENER WALLET CARD
(for children 3-6 years old)
After you have completed the vision test screener, please answer the following questions under their corresponding brackets below.

Child's Name: _____ Child's Age: _____

1. Vision in each eye (when either the right or the left eye is covered) ()
a. Visual acuity in either eye does not meet their corresponding age level as described below
b. Visual acuity in each eye meets their corresponding age level as described below
Choose a if the right and/or left eye cannot see beyond Level I (if your child is 3 years old)
Level II (if your child is 4-5 years old)
Level III (if your child is 6 years old)

2. From the scores achieved in the vision test screener, please calculate the difference in levels achieved between the right and left eyes by subtracting the highest level achieved in one eye from the other. ()
a. 3 b. 2 c. 1 d. 0
For example, when one eye sees Levels III, while the other eye cannot complete Level I, the difference is 3 (Level 3- Level 0 = 3).

Note: Do not report results achieved from the first trial test as it was meant for practice instructions only.

3. Have you or anyone else ever noticed the following in your child? ()
1) Drooping of the upper eyelid
2) An opaque white spot on the cornea (the front part of the eye that covers your dark brown iris)
3) Have previously been diagnosed by an ophthalmologist to have one of the following conditions: a congenital ptosis (drooping of the eyelid since birth), a cataract (a clouding of the lens inside the eye) or a corneal leucoma (a dense white opacity on the front part of the eye)
a. Yes, he or she has at least one of the above described condition b. Not sure c. No

4. Have you or anyone else ever noticed an eye that turns in (having a crossed-eye appearance), wanders out, wanders up/down or has an asymmetric appearance in the way the white part of the eyes look? ()
a. Always/Fairly often b. Only sometimes or infrequently c. Not sure d. Never
e. Have previously been diagnosed by an ophthalmologist to have an eye turn

5. Have you or anyone else ever noticed your child do the following: ()
1) Squints, tries to open his or her eyes wide or frowns when trying to see things
2) Tilts his or her head to see things
3) Hold things close to his or her face when trying to read or "hunches" close to watch TV
a. Yes to all 3 above b. Yes to 1 or 2 of the above-mentioned conditions c. Not sure d. Never

6. Have you or anyone else ever noticed unintentional jittery movement in your child's eye or an eye that drifts (move from one side to the other)? ()
a. Yes b. Did not understand this question c. Not sure d. Never

Figure 1 Original questionnaire of vision screening, which was turned into digital version for screening software.



Figure 2 First page of the amblyopia screening software.

RESULTS

In 2017, 324 preschoolers aged 3-6y old were recruited to the study. The mean age was 4.68±0.87y old and 178 of them were males. Four out of these 324 preschoolers was diagnosed as amblyopia by the professional tests, producing an amblyopia morbidity of 1.23% in this population. The distribution of the contributing causes were strabismus (n=2, 50%), anisometropia (i.e. interocular difference in SE of ≥1.5 D) (n=1, 25%), ametropia (i.e. astigmatism of >1.00 D, myopia >1.00 D or hyperopia > 2.50 D) (n=1, 25%), respectively (Table 1).

Of those 4 amblyopes detected by professional eye care providers, 3 of them were detected by the screening software. Therefore, the sensitivity of the screening software is 75%. Among the 320 non-amblyopes confirmed by professional eye care providers, 288 passed the screening software tests. Thus, the specificity of the screening software is 90.0%. In terms of predictive values, the positive and negative predictive value were 8.6% and 99.7%, respectively. The detailed results are shown in Table 2.

Table 1 Details of 4 amblyopic eyes

Age, y	Sex	Refraction(OD)	BCVA (OD)	Refraction(OS)	BCVA (OS)	Eye position	Detected by software?
4	M	+6.00/-1.00×180	0.7	+7.00/-1.00×180	0.3	Esotropia OS	Yes
4	M	+9.25/-0.75×5	0.3	+3.00/-0.50×175	0.8	Orthophoria	Yes
5	F	+3.25/-4.50×165	0.5	+2.75/-525×160	0.5	Orthophoria	Yes
5	M	+5.25/-1.50×15	0.8	+6.00/-1.25×180	0.8	Esotropia OS	No

BCVA: Best corrected visual acuity.

Table 2 The comparison of detection rate of amblyopia between the screening software and professional tests

Professional examinations	Home-based screening package		
	Positive	Negative	Total
Positive	3	1	4
Negative	32	288	320
Total	35	289	324

True positive rate: $3/4=75.0\%$; True negative rate: $288/324=90.0\%$;
Positive predictive value: $3/35=8.6\%$; Negative predictive value:
 $288/289=99.7\%$.

Regarding the costs, the expenditure for professional tests was estimated at \$7.5 per person, and it cost \$607.5 to detect an amblyopic preschooler. In comparison, the screening software cost near \$0 to diagnose an amblyopia using this strategy, except the cost of software development.

DISCUSSION

Through the investigation of preschoolers aged 3-6y old in outpatient department, Zhongshan Ophthalmic Center, this pilot study found that according to the present diagnosis criteria, the prevalence of amblyopia of preschoolers is 1.23%. The prevalence of amblyopia is higher than that of Australian, Korean, Japanese and American African reports, but similar to other Chinese studies (Table 3)^[8-18].

Concerning the appropriate age for amblyopia screening, there always exists a controversy. Flynn *et al*^[19] reviewed literature on the treatment for amblyopia and concluded that factors obviously related with effects of the treatment were the ages of the amblyopes, the types of amblyopia and the severity of the impaired vision before treatment. Williams *et al*^[20] carried out random experiments to prove that early intervention (8mo) can preferably prevent the occurrence of amblyopia. The infants' vision development is fairly unstable before 1y old and basically stable after that age, so the compliance and reactivity of infants' vision development make this age the most ideal time for screening^[21-22]. Schimitzek *et al*^[23] proposed 1year old as the optimal time for amblyopia screening. However, testability rates were generally lower in children under 3y of age (for review^[24]). Given children's young age, inferior participation and uncooperative nature, not a few researchers advocate the screening performed from the age of 3^[25]. Further, they believed that this age was still within the critical period for

vision development, older preschoolers were more compliant with the long-lasting and repetitive visual examinations and therapies so as to achieve a better outcome. In the present study, we employed the software to screen amblyopia and it turned out that this model was well-adopted by the preschool children and their parents.

Various screening systems had been assessed previously, among which visual acuity test was the simplest one. In a study using the same diagnosis criteria for the same ages of children, the sensitivity of the visual acuity test performed by licensed eye care providers (optometrists and pediatric ophthalmologists), with Lea Symbols VA, or with HOTV VA were found to be 63%, 76% and 73%, respectively. In contrast, the current screening software conducted by parents had the capability to detect 3 of the 4 "new" amblyope, which made the sensitivity of this model as high as 75.0%. In the same time, its specificity was also very satisfactory (90.0%). Also, this screening software, without necessitating professional knowledge or skills in diagnosing amblyopia, offers such efficiency at a relatively low cost. In Germany, screening amblyopia using visual acuity test by orthoptists, the cost of screening a preschooler and screening an amblyopic child was about 11.79-12.58 Euro and 878 Euro^[7], respectively. Professional tests cost an average of US Dollar (US\$) 607.5 /case of amblyopia diagnosed, whereas the cost was near US\$ 0/case for the screening software, except the cost of software development. For a country of China with more than 60 Million 3-6-year-old preschool children^[26], the economic advantage of the present screening software is significantly obvious.

One limitation of the present screening software was the lack of the test of the refractive error, another major risk factor of amblyopia. This could have attenuated the sensitivity of the screening software to some extent, as amblyopia screening by noncycloplegic retinoscopy or Retinomax autorefractor could achieve a sensitivity of 85%^[27]. Traditionally, the process of refraction needs expensive devices or manipulation by professional eye care providers. A relatively cheap and simple process, self-refraction, was recently developed and allowed users to measure refractive error by using adjustable spectacles. This technique was reported to have a almost equal accuracy with cycloplegic subjective refraction in Chinese children aged

Table 3 Prevalence of amblyopia in school-age children from population-based studies

Studies	Area	Sample size	Age range(y)	Prevalence (%)
Lim HT <i>et al</i> ^[9]	Seoul	36973	3-5	0.40
Lan <i>et al</i> ^[8]	Guangzhou, China	2308	3-6	1.04
Dan ^[10]	Nanjing, China	1695	3-4	1.47
Robaei D <i>et al</i> ^[11]	Australia	1741	6	0.7
Williams C <i>et al</i> ^[12]	UK	6081	7.5	0.7
Matsuo T <i>et al</i> ^[13]	Japan	6500-6900	1.5-3	0.14
Friedman DS <i>et al</i> ^[14]	American	2546	0.5-6	1.23
Mepeds ^[15]	American	6014	2.5-6	2.05
Lai YH <i>et al</i> ^[16]	Taiwan, China	618	3-6	5
Jamali P <i>et al</i> ^[17]	Iran	815	6	1.70
Chen ^[18]	Nanjing, China	5667	3-7	1.20
Present study	Guangzhou, China	324	3-6	1.23

12-17^[28]. Thus, the effect of the current screening software might be further enhanced if self-refraction is combined in the future. But above all, the production cost of the adjustable eyeglasses must be markedly reduced and the operability by preschoolers must be tested beforehand.

The amblyopia screening software provides a simple and highly effective method of screening for amblyopia, which is especially practical for developing countries of huge populations.

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