

Evaluation of a screening software for amblyopia

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一种新型弱视筛查软件的有效性测评研究

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摘要

目的: 评估一种新型弱视筛查软件的有效性。

方法: 2017年, 在门诊招募了324名3~6岁学龄前儿童。儿童的家长独立使用弱视筛查软件判断他们是否可能患有弱视, 然后所有儿童都进行专业的眼科检查。以眼科医生的诊断做对照, 对弱视筛查软件的筛查敏感性和特异性进行评价。

结果: 共324名儿童(176名男性, 148名女性)完成了整个试验流程。专科诊断了4名弱视患儿, 弱视筛查软件发现了其中3名。软件筛查的敏感性和特异性分别为75%和90%。专业诊断确诊一名弱视需要607美元, 而软件筛查除了开发外, 几乎0成本。

结论: 本研究表明, 弱视筛查软件是一种新型简单, 有效且性价比高的弱视筛查手段, 尤其适合发展中国家。

关键词: 学龄前儿童; 弱视; 筛查软件

Abstract

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

• **METHODS:** Totally 324 preschoolers aged 3–6 years 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 were 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 of the procedures. Four amblyopes were found by professional tests. And 3 of them were detected by the screening software. The sensitivity, specificity were 75%, 90%, respectively. Professional tests cost an average of US Dollar (US \$) 607/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 (eg. from natal to 8 years old), such as strabismus, severe refractive error, anisometropia and deprivation of form sense (eg. 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. 60min later, refractive error was determined by an auto-refractor (Topcon AR 8800, Tokyo, Japan), which was

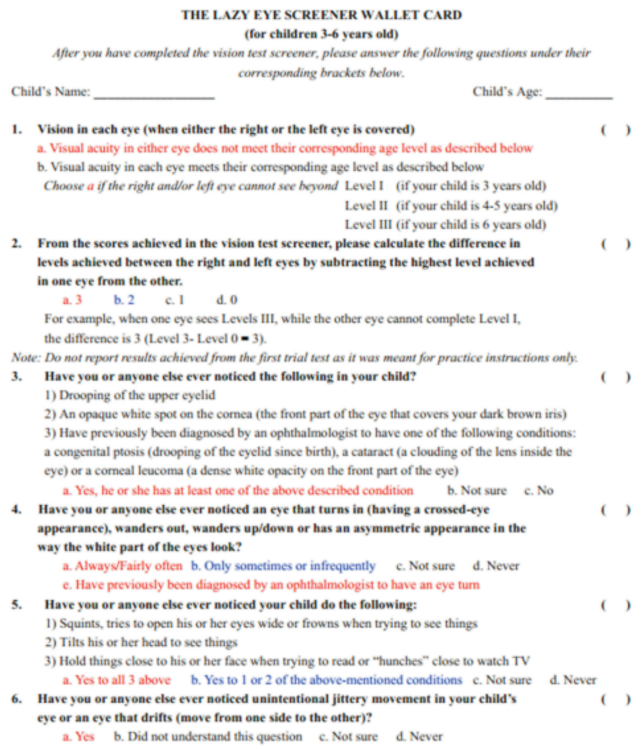


Figure 1 Original questionnaire of vision screening, which was turned into digital version for screening software.



Figure 2 First page of the amblyopia screening software.

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

Table 1 Details of 4 amblyopic eyes

Age, a	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%.

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

Studies	Areas	Sample size	Age range(a)	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]	America	2546	0.5-6	1.23%
Mepeds ^[15]	America	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%

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.

RESULTS

In 2017, 324 preschoolers aged 3-6 years old were recruited to the study. The mean age was 4.68±0.87 years 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.

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 3-6 years old in outpatient department, Zhongshan Ophthalmic Center, this polit 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 1 years 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 3 years old (for review^[24]). Given children's young age, inferior participation and uncooperatative 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. Contrastly, 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 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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