Article ▸ A Comparison of Performance on the NYSOA King-Devick Test between Mexican and American School-aged Children

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ABSTRACT

Background: The King-Devick Test has long been used to screen reading eye movements in school-aged children. A normative database has been developed for use in the United States (U.S.), but there is limited information on its application internationally. The purpose of the current study is to compare the performance on the King-Devick Test of Mexican school-aged children to the established norms of U.S. children.

Methods: Six- (n=33), nine- (n=28), twelve- (n=33), and fourteen-year-old (n=26) children from six geographically-separate Mexican states were enrolled. Subjects completed subtests I-III of the King-Devick Test in a seated position under normal room illumination. Each subtest was timed and behavioral characteristics were assessed. Performance of each age group was compared to the U.S. database using simple, paired t-tests with a probability factor of 0.05.

Results: There was a statistically significant difference in performance between 14-year-old children in the Mexican and U.S. group (p=0.003). No significant difference was found in the respective comparisons between six-, nine-, and twelve-year-old Mexican and U.S. children (p>0.05).

Conclusion: Performance on the King-Devick Test is similar between Mexican and U.S. children. It would be appropriate to use this test in a similar manner for evaluating reading eye movements in Mexican, school-aged children.

Keywords: King-Devick, Mexico, reading, saccadic eye movements, United States

Introduction

The New York State Optometric Association King-Devick (NYSOA K-D) Test has recently gained popularity as a rapid screening test for concussion in sports. Though a multitude of recent studies have supported its use in diagnosing concussion,[1-4] the test was initially developed for screening reading eye movements in school-aged children. In 1983, a study evaluating the performance of 1202 children from Queens, New York produced a normative database of children age six through fourteen.[5] Given the large sample size and repeatability, many vision care providers have used this data for comparison when diagnosing reading eye movement disorders.[6] For the test to be applied internationally, however, it is pertinent that it be evaluated for validity throughout various educational systems, cultural backgrounds, and socioeconomic states.[7] The purpose of the current study is to evaluate the performance of Mexican children on the NYSOA K-D as compared to the established, American normative database.

Methods

The NYSOA-KD consists of one demonstration plate followed by three testing plates. Each plate contains an array of 40 numbers grouped five to a line on each of eight lines. The demonstration and Test I plate have lines as a guide, and Tests II and III require the subject to rely solely on eye movements to complete the task (Figure 1). Test II has the same overall spacing as Test I in terms of the vertical space between the lines. All test plates use the entire left-to-right dimension of the page. Test III reduces the vertical space between lines significantly, which places an additional burden on the test taker to keep their place. The subject/patient is instructed to call off the numbers as fast as they can. Each section is individually timed and summed to find the total completion time. The subject/patient is also evaluated for qualitative measures indicative of poor reading

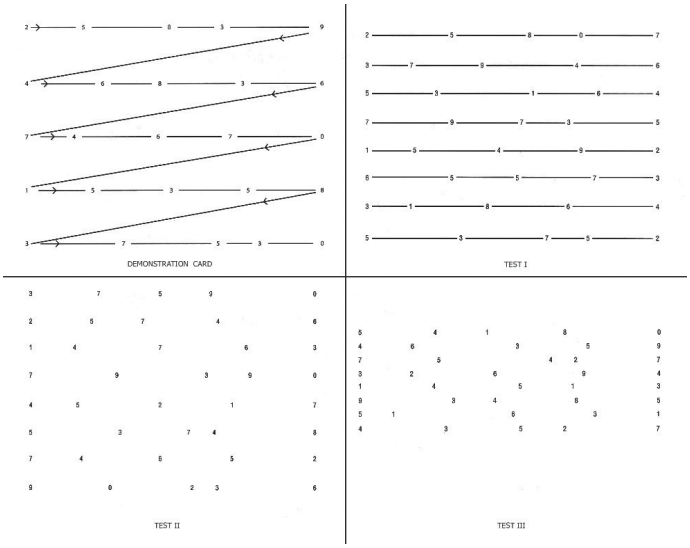

Figure 1. *A sample of the NYSOA K-D Saccadic Eye Movement Test*

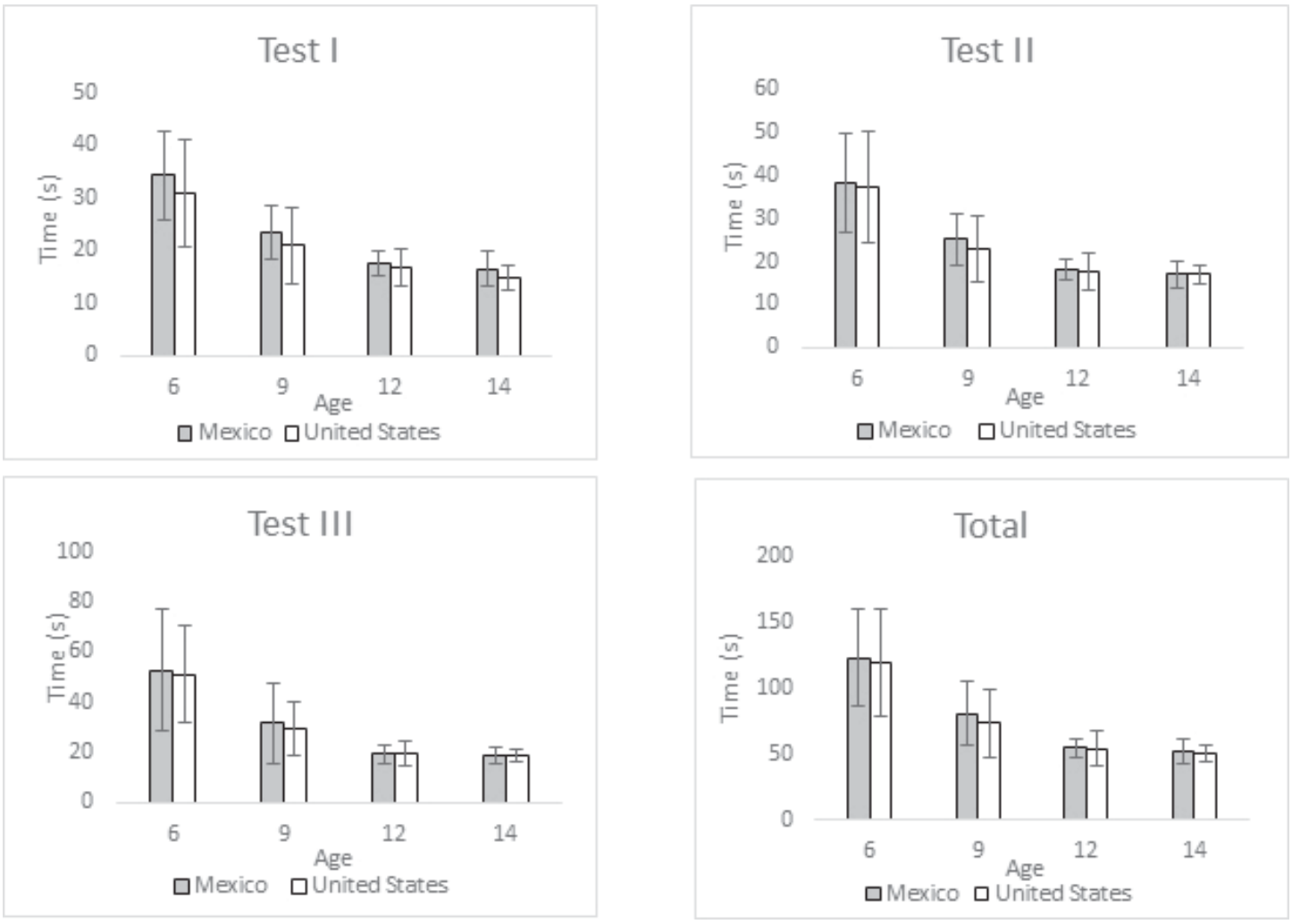

Figure 2. *Average completion time of (a) Test I, (b) Test II, (c) Test III, and (d) total time on the NYSOA King-Devick Saccadic Test by school-aged children in Mexico and the United States. Error bars are standard deviation. *Statistically significant (p≤0.05).*

eye movements, such as head and body movement, guiding with the finger, and skipping numbers or lines.

For the current study, subjects were recruited from elementary schools located in six geographically-separate Mexican states. Six- (n=33), nine- (n=28), twelve- (n=33), and fourteen-year-old (n=26) students currently enrolled in a regular education program with no special education were eligible to participate. The data from two individuals (ages six and fourteen) were considered statistical outliers and were excluded from the analysis. In addition to timing the NYSOA-KD, eight researchers evaluated vertical and horizontal head movement, upper body movement, body rotation, presence of head support, guiding with finger, line and number repetitions and omissions, pauses, and stops. Each condition was rated as mild, moderate, or excessive, but the information was reduced to being either present or absent for ease of analysis.

All tests were performed in the morning to prevent fatigue. The children were brought into a separate testing room one at a time and instructed how to take the test. The rooms had adequate lighting that is standard for Mexican schools. Before starting, the children were made to feel as comfortable as possible in their chairs, and the children were reminded to read as quickly as possible. The tester sat across the table from the children to observe their behavior while performing the task. Though they were instructed not to, several children attempted to use their fingers to assist in keeping their place on the page. In fact, most of the 6-year-olds attempted to use their fingers in this way.

Results

A summary of the timed portion of the test may be found in Table 1 and Figure 2. The findings are compared to those in the Lieberman study, which have become the established norms for testing in the United States. Simple, paired t-tests with a probability factor of 0.05 were used to determine significance. Of note, the average completion time on Test I was statistically significant between 14-year-olds in Mexico as compared to those in the U.S. (p=0.003). There were no significant differences between average completion times of any other subtest by U.S. and Mexican children of similar ages (p≤0.05). Both Mexican and U.S. children demonstrated similar trends in improvement as age increased.

A qualitative analysis of performance on the NYSOA-KD is outlined in Table 2 and represented graphically in Figure

Table 1: Average Completion Time of the NYSOA King-Devick Saccadic Test by School-Aged Children by Country

Section	Country	6 Years Old	9 Years Old	12 Years Old	14 Years Old
Test I	MX	34.3 (± 8.6)	23.6 (± 5.0)	17.5 (± 2.4)	16.6 (± 3.3)
	US	31.0 (± 10.1)	21.0 (± 7.2)	16.9 (± 3.6)	14.9 (± 2.4)
		p=0.09	p=0.07	p=0.37	p=0.003*
Test II	MX	38.2 (± 11.5)	25.2 (± 6.0)	18.0 (± 2.5)	17.0 (± 3.1)
	US	37.1 (± 13.0)	22.9 (± 7.5)	17.7 (± 4.4)	16.9 (± 2.3)
		p=0.67	p=0.12	p=0.75	p=0.85
Test III	MX	52.5 (± 24.3)	31.7 (± 16.1)	19.0 (± 3.4)	18.6 (± 3.4)
	US	51.0 (± 19.4)	29.5 (± 10.8)	19.4 (± 5.3)	18.7 (± 2.5)
		p=0.72	p=0.34	p=0.68	p=0.87
Total	MX	123.0 (± 36.8)	80.5 (± 24.2)	54.5 (± 7.4)	52.1 (± 9.0)
	US	119.0 (± 40.9)	73.4 (± 26.0)	54.0 (± 13.5)	50.4 (± 5.8)
		p=0.62	p=0.17	p=0.84	p=0.24

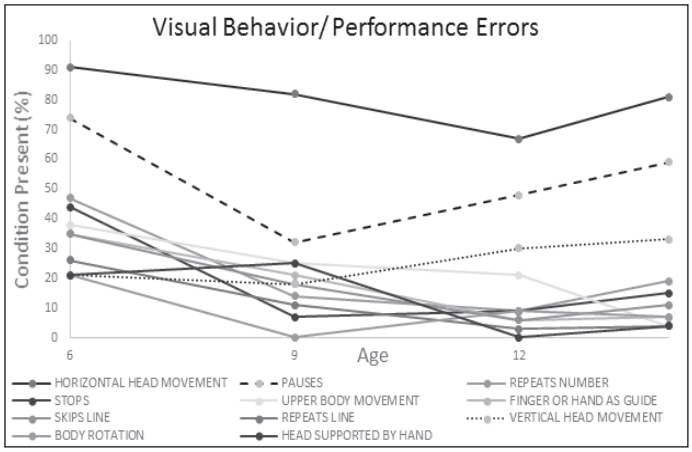

Figure 3. *Percent of individual behavioral abnormalities and errors during NYSOA-KD testing of six-, nine-, twelve-, and fourteen-year-old Mexican children.*

3. As noted earlier, though each condition was initially rated as mild, moderate, or severe, the information was condensed to being either present or absent for ease of interpretation. To the author's knowledge, there are no known studies on U.S. children's performance in this area to which a comparison may be made.

Every condition evaluated was present to some degree in the six-year-old population. The greatest area of difficulty was noted in horizontal head movement (91%), which is an expected finding for this age group.[8] Other behavioral tendencies commonly found in the six-year-old group included upper body movement and using the finger as a guide. The most frequent errors in this age group were repeating numbers and skipping numbers or even entire lines.

Nine-year-olds performed significantly better on all qualitative measures except for horizontal head movement. All visual behavioral abnormalities and performance errors remained present in small amounts. This reduction was seen in twelve- and fourteen-year-olds, but pausing errors and horizontal head movement were persistent throughout all age groups.

Discussion

The results of the current study demonstrate a striking similarity in performance on the NYSOA K-D test between

Table 2: Qualitative Measures of Performance on NYSOA King-Devick Saccadic Eye Test by Mexican 6-year-olds (n=34), 9-year-olds (n=28), 12-year-olds (n=33), and 14-year-olds (n=27)

	6 YEARS OLD	9 YEARS OLD	12 YEARS OLD	14 YEARS OLD
VERTICAL HEAD MOVEMENT	7 (21%)	5 (18%)	10 (30%)	9 (33%)
HORIZONTAL HEAD MOVEMENT	31 (91%)	23 (82%)	22 (67%)	22 (81%)
UPPER BODY MOVEMENT	13 (38%)	7 (25%)	7 (21%)	1 (4%)
BODY ROTATION	7 (21%)	0 (0%)	3 (9%)	2 (7%)
HEAD SUPPORTED BY HAND	7 (21%)	7 (25%)	0 (0%)	1 (4%)
FINGER OR HAND AS GUIDE	12 (35%)	6 (21%)	2 (6%)	2 (7%)
REPEATS LINE	9 (26%)	3 (11%)	1 (3%)	1 (4%)
REPEATS NUMBER	16 (47%)	4 (14%)	3 (9%)	5 (19%)
SKIPS LINE	12 (35%)	5 (18%)	2 (6%)	3 (11%)
PAUSES	25 (74%)	9 (32%)	16 (48%)	16 (59%)
STOPS	15 (44%)	2 (7%)	3 (9%)	4 (15%)

Mexican and U.S. children. This finding sheds light on academic influences in visual development. Children in the U.S. often begin formal schooling earlier than Mexican children. A typical U.S. child will enter Kindergarten at the age of 4 and the 1st grade by age 5. The formal education system in Mexico starts children in 1st grade at the age of 6. One might suggest that starting education earlier would cause the visual system to mature faster, but the current study provides no evidence of this.

Language must also be considered when comparing performance on this test. Specifically, the number of syllables used to pronounce each digit is greater in the Spanish language than in English (e.g., 'cuatro' is two syllables, but four is one syllable). In fact, the numbers 'cero' through 'nueve' contain seventeen syllables compared to only twelve for 'zero' through 'nine'. This may contribute to the statistical significance between average completion times on Test I for U.S. and Mexican 14-year-old children. It is expected that the oldest group of each nationality would have the most developed

eye movements (and thus perform the test faster) compared to their younger peers. Likewise, Test I has lines to guide eye movements, which should theoretically reduce variation within the test group. Thus, it would be reasonable to suggest that performance on this subtest within this age group is most susceptible to the confounding variable of language. Furthermore, it may not be appropriate to correlate differences in oculomotor function with the performance on this subtest.

The reliability of the NYSOA K-D test in children younger than age 7 has also been questioned for consistency in test-retest classification, the learning effect, and the ability to complete Test III.[9] All but one of the 6-year-old Mexican children were able to complete Tests I, II, and III. The last test plate, however, did show the greatest variation in performance within this age group. This was also the area of most improvement between six- and nine-year-olds, which may indicate rapid development in the coordination of eye movements at this age. This finding is consistent with previous research in this area.[8]

Behavioral analysis of the Mexican children's performance on the NYSOA K-D provided great insight on the maturation of the oculomotor system. Though body movement was nearly extinguished by 14 years of age, head movement was still noted in the majority of 14-year-old participants. This suggests that the ability to move the eyes independently of the head while performing a demanding task is the most advanced form of oculomotor control. The gradual decline in such characteristics as upper body movement, body rotation, and using their finger as a guide demonstrates the maturation of these processes from age 6 to 14, reaching adult-like form by age 14.

A step-wise decline in performance errors over age was also noted. Though pauses associated with fixation loss were present in all age groups, there were significantly fewer stops in the 9- to 14-year-old groups compared to the 6-year-olds. This may be a result of developing visual processing skills. At age six, the child does not have the capacity to remember and to relocate their place when fixation is lost. This ability appears to be gained by age 9. The development of visual processing may also be found in the reduction of number repetition over age. By age nine, most children are able to process the numbers they are calling out and have the visual memory to recognize their place when fixation is lost. This ability is only present in approximately half of six-year-old Mexican children. It would be interesting to determine whether such trends are also present in children in the U.S. educational system.

Conclusion

Performance on the NYSOA King-Devick Saccadic Eye Movement Test is similar between Mexican children and U.S. children. Mexican vision care providers may use the current normative data for comparison when diagnosing reading eye movement disorders.

Acknowledgement

The following clinicians were involved in testing and collecting data: Dra Rocío Leon Cabrera, Dra Ma. Lydia Alva Pacheco, Dra Sandra Villegas Zúñiga, Dra Silvia Buitrón Flores, Dr Jaime de Loera Cervantes , Dr José Juan Romo Gtz, Dr José Tarango Mendoza , Dr Francisco Pérez Robles, Dr José Luis Chessal Rivero, Dr Stewar Saucedo Salcedo, and Dr Jorge Aranda Tello.

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Konynenbelt B, Harris P, Pérez Robles F. A comparison of performance on the NYSOA King-Devick Test between Mexican and American school-aged children. Optom Vis Perf 2016;4(6):220-3

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