The Differences between Visual Acuity Using the Standard Snellen Chart and the Novel Chart (Sak Charts)

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Objective: *To determine the difference in visual acuity (VA) when using the standard Snellen chart and the novel chart (Sak charts) in the groups which have and have not been examined by the standard Snellen Chart before.*

Material and Method: *This research is a diagnostic study divided into two groups; groups one involves the samples which have never been examined using the standard Snellen Chart before (n = 149) and group two is done on the samples which have experienced with the Snellen Chart (n = 148). The research was conducted at Thammasat University Hospital and the area around Pathumthani province by collecting data of the general population presented with descriptive statistics and visual acuity in Decimal, LogMAR and the number of letters analysed by paired t-test and Wilcoxon Signed Ranks Test ($p<0.05$).*

Results: *In group one, there are no significant differences in VA between the standard Snellen chart and SAK Chart No. 1 with Decimal ($p = 1.000$), Log MAR ($p = 1.000$), no significant differences in VA between the standard Snellen Chart and SAK Chart No. 2 with Decimal ($p = 1.000$), Log MAR ($p = 1.000$), and no significant differences in VA between SAK Chart No. 1 and SAK Chart No. 2 with Decimal ($p = 1.000$), Log MAR ($p = 1.000$). In part 2, on the other hand, there are significant differences of VA between the standard Snellen Chart and SAK Chart No. 1 with Decimal ($p<0.001$) and Log MAR ($p<0.001$), significant differences in VA between the standard Snellen Chart and SAK Chart No. 2 with Decimal ($p<0.001$), Log MAR ($p<0.001$).*

Conclusion: *No significant differences in VA between the standard Snellen Chart and SAK Chart is found in the samples which have never been examined using the standard Snellen Chart before, but significant difference in VA is observed in the group of people who have been examined using the standard Snellen chart before.*

Keywords: *Visual acuity, Snellen chart, SAK chart*

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The standard Snellen Chart was invented a hundred years ago, and was widely used during in 1950[1]. In clinical practice to use this for evaluate visual acuity (VA) in screening, monitoring and evaluation after treatment. The use of numbers or letters on the chart, which in practice is examined using a series of numbers that are the same. We found that patients have examined by the standard Snellen chart before, they have experienced and recognized numbers or letters on the chart, made visual acuity has an error. Patients might read the number on the check was correct, rather than reality. That the review of the literatures found that memory divided by the duration, has two types of short-term memory and long-term memory. The long-term memory was created by stimulating Visual sensory[2]. To be examined by read the same set of numbers in The standard Snellen chart may memorize numbers and influence in VA.

The novel charts (SAK Charts) is applies from principles of invented the standard Snellen chart. There are three models by introducing the numbers that appear in the chart and create a new series of numbers. Each numbers in the novel charts (SAK Charts) was created under the optotype and visual angle principle. We expect to use new series of numbers can increase the accuracy of the measured VA. The novel charts (SAK Charts) consist of 3 charts, SAK Charts No. 1 is a new series of numbers these reversed from the standard Snellen chart (reverse Snellen chart), SAK Charts No. 2 is a new series of numbers these modified

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from the standard Snellen chart (modified Snellen chart) and SAK Charts No. 3 is the standard Snellen chart (the original).

Although there are currently developing Early Treatment Diabetic Retinopathy detection sheet Study (ETDRS) chart that provides reliability and validity rather than the standard Snellen Chart. It was found that measuring VA will have very different effects in the range of sight worse than 20/200[3]. Therefore, The novel charts (SAK Charts) examine VA between 2/20 to 2/200, so it might be enough to useful evaluated.

The research on screening health problems of children in primary school found that the standard Snellen chart is useful for VA screening[4]. It's quite simple, friendly, easy use and fashionable in general clinical practice. We think the development of the novel charts (SAK Charts) and reduce limitation of the standard Snellen chart, It could be useful to patients in the future.

Material and Method

Research design

This research is a diagnostic study divided into two groups; group one involves the samples which have never been examined using the standard Snellen chart before and group two is done on the samples which have experienced with the standard Snellen chart.

Samples

Population over the age of 8 years (on the date of the signed letter of consent form) is calculated using a formula of the compare population average[5] calculate the sample size has a 133 people divided into two groups by the research in each part with the selection criteria established by the population inclusion and exclusion criteria as follows:

Inclusion criteria

Literate in reading numbers and can communicate adequately.

Cognitively functional and co-operative.

Exclusion criteria

VA is finger counting or worse.

Patient has concurrent underlying conditions that affect cognitive ability, such as dementia.

In group one of research has additional inclusion criteria, never been examined using the standard Snellen chart before and group two of research, done on the samples which have experienced

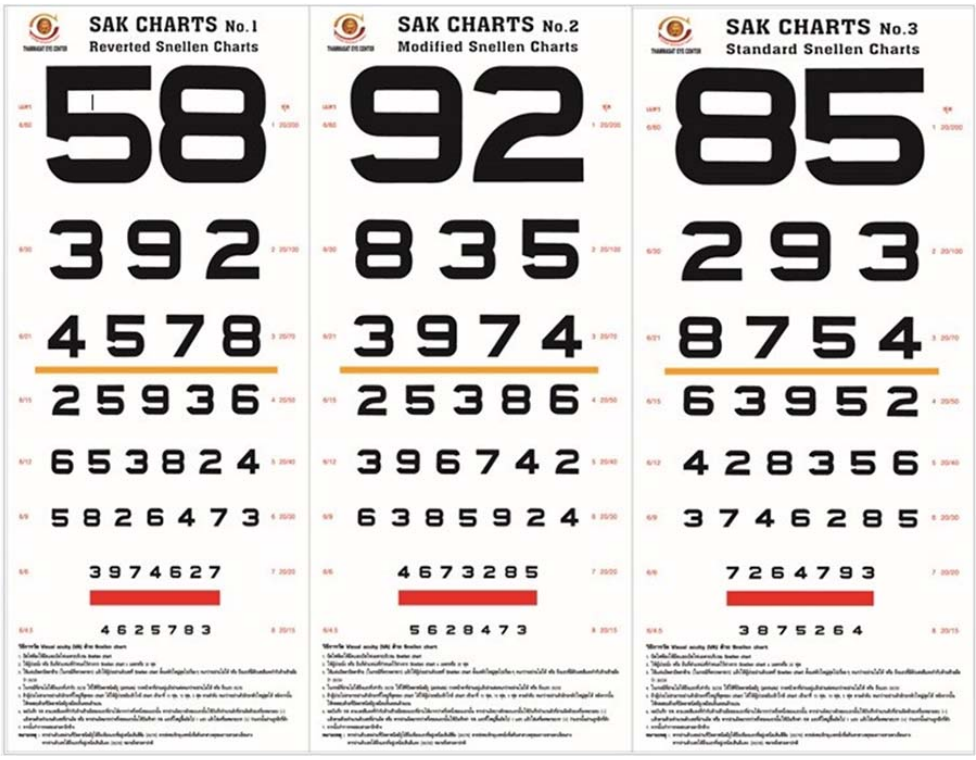

Fig. 1 The novel chart (Sak charts).

Table 1. Demographic data in group one

Information	Never been examined using the standard Snellen chart before	
	Right, n (%)	Left, n (%)
Numbers	74	75
Gender		
Male	37 (50.0)	34 (45.3)
Female	37 (50.0)	41 (54.7)
Age		
Means ± SD, max-min	18.3±15.6, 9 to 63	18.5±14.0, 9 to 63
Education		
Primary	57 (77.0)	54 (72.0)
Elementary	5 (6.8)	9 (12.0)
Bachelor's degreeand over	12 (16.2)	12 (16.0)
Underlying disease		
No	68 (91.9)	73 (97.3)
Yes	6 (8.1)	2 (2.7)
Diabetes	3 (4.1)	0 (0.0)
Hypertension	4 (5.4)	1 (1.3)
Dyslipidemia	2 (2.7)	0 (0.0)
Others	0 (0.0)	1 (1.3)
Ophthalmic disease		
No	69 (93.2)	66 (88.0)
Yes	5 (6.8)	9 (12.0)
Retina	0 (0.0)	0 (0.0)
Glaucoma	0 (0.0)	0 (0.0)
Cornea	1 (1.4)	1 (1.3)
Others	4 (5.4)	8 (10.7)
History of eye trauma		
No	74 (100.0)	75 (100.0)
Yes	0 (0.0)	0 (0.0)

with the standard Snellen chart at least once in one year until now (on the date of the signed letter of consent form).

The research was conducted at Thammasat University Hospital and the area around Pathumthani province on July 2015 to June 2016, collected demographic data include gender, age,education, underlying disease, ophthalmic disease, history of eye trauma and history of examined by the standard Snellen chart in 1 year ago. VA was examined with the standard Snellen chart and the novel charts (SAK charts) and performed in 20/20 to 20/200 feet unit, 1.0 to 0.0 Log MAR, 0.1 to 1.0 Decimal unit and 0 to 34 number of letters, randomized right or left eye before, separated populations in group one and two. The research presented with descriptive statistics, means and standard deviations. To analysed by paired t-test and Wilcoxon Signed Ranks test (p<0.05) and use statistical analysis by SPSS 21.0 version. This research is approved by the Research Ethics Committee in human 1 , Faculty of medicine, Thammasat University.

Results

Collect data from a population of 297 people (eye), group one involves the samples which have never been examined using the standard Snellen chart before. There is a sample of 149 people (eye) into right eye 74 eye and left eye 75 eye found that the majority of female 78 people (52.3%), average ages of 18.4 years, primary education level which most people is 111 people (74.5%), found underlying disease 8 people (5.4%), hypertension is maximum 5 people (3.4%), found ophthalmic disease 14 people (9.4%) as the other ophthalmic disease 8.1% and cornea disease 1.3%, not found to have history of eye trauma. Once considered by the right and left eyes, found that the population is quite similar as shown in Table 1.

Group two is done on the samples which have

Table 2. Demographic data in group two

Information	Experienced with the standard Snellen chart	
	Right, n (%)	Left, n (%)
Numbers	73	75
Gender		
Male	31 (42.5)	24 (32.0)
Female	42 (57.5)	51 (68.0)
Age		
Means ± SD, min-max	60.7±13.6, 23 to 85	58.4±15.6, 18 to 80
Education		
Lower than primary	-	3 (4.0)
Primary	23 (31.5)	23 (30.7)
Elementary	18 (24.7)	22 (29.3)
Bachelor's degree and over	32 (43.8)	27 (36.0)
Underlying disease		
No	23 (31.5)	20 (26.7)
Yes	50 (68.5)	55 (73.3)
Diabetes	25 (34.2)	24 (32.0)
Hypertension	39 (53.4)	32 (42.7)
Dyslipidemia	26 (35.6)	26 (34.7)
Heart disease	6 (8.2)	4 (5.3)
Others	2 (2.8)	8 (10.7)
Ophthalmic disease		
No	0 (0.0)	0 (0.0)
Yes	73 (100.0)	75 (100.0)
Retina	10 (13.7)	16 (21.3)
Glaucoma	16 (21.9)	20 (26.7)
Cornea	21 (28.8)	23 (30.7)
Others	38 (52.1)	26 (34.7)
History of eye trauma		
No	68 (93.2)	74 (98.7)
Yes	5 (6.8)	1 (1.3)
Number of examined VAin 1 year before		
Means ± SD, min-max	4.1±3.1, 2 to 20	3.1±1.6, 2 to 11

experienced with the standard Snellen chart 148 people (eye) into right eye 73 eye and left eye 75 eye. There is majority of female 93 people (62.8%), average ages of 59.5 years, education level found that Bachelor's degree and over which the most is 59 people (39.9%), found underlying disease 105 people (70.9 %), hypertension is maximum 71 people (48.0%), found ophthalmic disease 65 people (43.2%) as the other ophthalmic disease, found history of eye trauma 6 people (4.1%), Means of number of examined VA in 1 year before is 3.6 times. The comparison between the right and left eye by data looks similar, as shown in Table 2.

In group one, there are no significant differences in VA between the standard Snellen Chart and SAK Chart No. 1 with Decimal (p = 1.000), Log MAR (p = 1.000), no significant differences in VA between the standard Snellen chart and SAK chart No. 2 with Decimal (p = 1.000), Log MAR (p = 1.000) and number of letters (p=0.303), and no significant differences in VA between SAK chart No. 1 and SAK chart No. 2 with Decimal (p = 1.000), Log MAR (p = 1.000) and number of letters (p = 0.719). In number of letters which weak reliability and validity found that significant differences in between the standard Snellen chart and SAK chart No. 1 (p = 0.041).

In group two, there are significant differences of VA between the standard Snellen Chart and SAK Chart No. 1 with Decimal (p<0.001), Log MAR (p<0.001) and number of letters (p<0.001), significant differences in VA between the standard Snellen Chart and SAK

Table 3. The differences of visual acuity between the standard Snellen chart and SAK chart in group one (never been examined using the standard Snellen chart before) (n = 149)

VA first eye	Mean	SD	Mean difference	t-test	*p*-value[1]
VA decimal					
Standard Snellen chart	0.98	0.09			1.000[2]
SAK chart No. 1	0.98	0.09			
VA Log MAR					
Standard Snellen chart	0.01	0.05			1.000[2]
SAK chart No. 1	0.01	0.05			
Letters					
Standard Snellen chart	33.38	2.45	0.07	2.065	0.041[1,*]
SAK chart No. 1	33.30	2.52			
VA decimal					
Standard Snellen chart	0.98	0.09			1.000[2]
SAK chart No. 2	0.98	0.09			
VA Log MAR					
Standard Snellen chart	0.01	0.05			1.000[2]
SAK chart No. 2	0.01	0.05			
Letters					
Standard Snellen chart	33.38	2.45	0.05	1.033	0.303[1]
SAK chart No. 2	33.32	2.32			
VA decimal					
SAK chart No. 1	0.98	0.09			1.000[2]
SAK chart No. 2	0.98	0.09			
VA Log MAR					
SAK Chart No. 1	0.01	0.05			1.000[2]
SAK Chart No. 2	0.01	0.05			
Letters					
SAK Chart No. 1	33.30	2.52	-0.02	-0.360	0.719[1]
SAK Chart No. 2	33.32	2.32			

[1] paired t-test, [2] wilcoxon signed ranks test * $p<0.05$

Chart No. 2 with Decimal ($p<0.001$), Log MAR ($p<0.001$) and number of letters ($p<0.001$), and no significant differences in VA between SAK chart No. 1 and SAK chart No. 2 with Decimal ($p = 1.000$), but significant differences in Log MAR ($p = 0.031$) and number of letters ($p = 0.09$).

Discussion

In group one and two,which are randomized and separated in right eye and left eye for first VA measurement, demographics are similar. From our hypothesis is purposed, in group one (those who have never been examined using the standard Snellen chart) has no significant differences in VA between the standard Snellen Chart, SAK Chart No. 1 and SAK Chart No. 2. The results are in favor of our hypothesis in decimal VA and Log MAR VA are reliable and are standard for research and use in clinical practice[6]. But number of letters which weak reliability and validity for evaluate VA found that significant differences, be possible number of letters is crude and variable in each line of chart[7]. In group two (experienced with the Snellen chart), from our hypothesis is significant differences in VA between the standard Snellen chart and SAK Chart No. 1 or SAK Chart No. 2. As the literature about the memory, visual memory can stimulate to creat short term memory, then it is stimulated repeatly, the long-term memory is created[8-10]. So the populations had experienced with the Snellen chart before, they may memorize series of numbers and influence in their VA. The result in group two is similar to our hypothesis, there are significant differences of VA in decimal and LogMAR between the standard Snellen chart and SAK Chart No. 1 and between the standard Snellen chart and SAK Chart No. 2. Our results suggest visual acuity in the standard Snellen chart better

Table 4. The differences of VA between the standard Snellen chart and SAK chart in group two (experienced with the Snellen chart) (n = 148)

VA First eye	Mean	SD difference	Mean	t-test	*p*-value[1]
VA Decimal					
Standard Snellen chart	0.78	0.27	0.12	8.752	<0.001*
SAK chart No. 1	0.66	0.28			
VA Log MAR					
Standard Snellen chart	0.15	0.22	-0.08	-7.765	<0.001*
SAK chart No. 1	0.23	0.24			
Letters					
Standard Snellen chart	27.57	8.49	4.09	9.753	<0.001*
SAK chart No. 1	23.48	9.43			
VA decimal					
Standard Snellen chart	0.78	0.27	0.13	9.727	<0.001*
SAK chart No. 2	0.65	0.28			
VA Log MAR					
Standard Snellen chart	0.15	0.22	-0.09	-8.889	<0.001*
SAK chart No. 2	0.24	0.25			
Letters					
Standard Snellen chart	27.57	8.49	4.59	11.302	<0.001*
SAK chart No. 2	22.98	9.30			
VA decimal					
SAK chart No. 1	0.66	0.28	0.01	1.887	0.061
SAK chart No. 2	0.65	0.28			
VA Log MAR					
SAK chart No. 1	0.23	0.24	-0.01	-2.173	0.031*
SAK chart No. 2	0.24	0.25			
Letters					
SAK chart No. 1	23.48	9.43	0.50	2.666	0.009*
SAK chart No. 2	22.98	9.30			

1paired t-test, * $p<0.05$

than SAK Chart No. 1 and SAK Chart No. 2. We assume that the populations experience of the Snellen chart have developed visual memory of the series of numbers, resulting in a higher visual acuity reading.

Conclusion

No significant differences in VA between the standard Snellen chart and SAK chart is found in the samples which have never been examined using the standard Snellen chart before, but significant difference in VA is observed in the group of people who have been examined using the standard Snellen chart before. As possible in general population, SAK chart No. 1 and SAK chart No. 2 can measure VA in decimal and Log MAR likely with the standard Snellen chart. In the other hand, the general population have experienced with the Snellen chart before, they may have VA in decimal and Log MAR better than the real VA.

Limitation

Demographic data in group one and two are quite different in age, education and underlying disease. Although the objective of the research is not to compare population 2 group. But if the population is similar, it would make a comparison of the data better than. Limitation occurred because the population in group 1 which have never been examined using the standard Snellen chart before in the general population was relatively small.

What is already known on this topic?

In clinical practice to use the standard Snellen chart for evaluate visual acuity (VA) in screening, monitoring and evaluation after treatment. That the review of the literatures found that memory divided by the duration, has two types of short-term memory and long-term memory. The long-term memory was created

by stimulating Visual sensory. To be examined by read the same set of numbers in the standard Snellen chart may memorize numbers and influence in VA. The innovation of the novel charts that have variation of series of numbers. The researcher's hypothesis purposes that can reduce limitation of the standard Snellen chart.

What this study adds?

No significant differences in VA between the standard Snellen chart and SAK chart is found in the samples which have never been examined using the standard Snellen chart before, but significant difference in VA is observed in the group of people who have been examined using the standard Snellen chart before. As possible in general population, SAK chart No. 1 and SAK chart No. 2 can measure VA in decimal and Log MAR likely with the standard Snellen chart. In the other hand, the general population have experienced with the Snellen chart before, they may have VA in decimal and Log MAR better than the real VA.

Potential conflicts of interest

None.

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ความแตกต่างของผลการวัดระดับสายตาเมื่อใช้แผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) และการใช้แผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ต (SAK charts)

ศักดิ์ชัย วงศกิตติรักษ์, ปกรณ์กิจ พฤกษาอุดมชัย

วัตถุประสงค์: เพื่อหาความแตกต่างของผลการวัดระดับสายตาเมื่อใช้แผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) และการใช้แผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ต (SAK charts) ในกลุ่มที่ไม่เคยและเคยได้รับการตรวจโดยใช้ Snellen chart มาก่อน

วัสดุและวิธีการ: เป็นการวิจัยแบบการตรวจวินิจฉัย (Diagnostic study) แบ่งการวิจัยออกเป็น 2 ส่วน ทำในกลุ่มคนที่ไม่เคยและเคยได้รับการตรวจด้วยแผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) เก็บข้อมูลประชากรเป้าหมายที่โรงพยาบาลธรรมศาสตร์ฯ และพื้นที่จังหวัดปทุมธานี อายุมากกว่า 8 ปีขึ้นไป โดยมีเกณฑ์คัดเข้าและคัดออกชัดเจน คำนวณขนาดตัวอย่างได้กลุ่มละ 133 คน ใช้แบบสอบถามข้อมูลทั่วไปเกี่ยวกับประชากรนำเสนอผลด้วยสถิติเชิงพรรณนาและวัดระดับสายตาบันทึกเป็นค่าหน่วย Decimal, Log MAR และจำนวนตัวอักษร (Letters) เปรียบเทียบความแตกต่างใช้สถิติ paired t-test และ Wilcoxon signed ranks test ที่ค่าความเชื่อมั่น $p<0.05$ วิเคราะห์ข้อมูลด้วยระบบฐานข้อมูล SPSS 21.0

ผลการศึกษา: ส่วนที่ 1 และ 2 เก็บข้อมูลประชากรได้ 149 คน(ตา) และ 148 คน(ตา) ส่วนที่ 1 กลุ่มที่ไม่เคยวัดสายตา ไม่พบความแตกต่างระดับสายตาจากแผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) เทียบกับแผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ตแผ่นที่ 1 (SAK chart No. 1) โดย $p = 1.000$ (Decimal) และ $p = 1.000$ (Log MAR) ตามลำดับ ไม่แตกต่างเมื่อเทียบกับแผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ตแผ่นที่ 2 (SAK chart No. 2) โดย $p = 1.000$ (Decimal) และ $p = 1.000$ (Log MAR) ตามลำดับ และไม่แตกต่างเมื่อเทียบระหว่างแผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ตแผ่นที่ 1 (SAK chart No. 1) กับแผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ตแผ่นที่ 2 (SAK chart No. 2) โดย $p = 1.000$ (Decimal) และ $p = 1.000$ (Log MAR) ตามลำดับ ส่วนที่ 2 กลุ่มเคยวัดสายตาพบความแตกต่างระดับสายตาจากแผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) เทียบกับการใช้แผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ตแผ่นที่ 1 (SAK chart No. 1) โดย $p<0.001$ (Decimal) และ $p = 0.001$ (Log MAR) ตามลำดับ และแตกต่างเมื่อเทียบกับแผ่นตรวจแบบใหม่ ชนิดศักดิ์ชาร์ตแผ่นที่ 2 (SAK chart No. 2) โดย $p<0.001$ (Decimal) และ $p = 0.001$ (Log MAR) ตามลำดับ

สรุป: ไม่พบความแตกต่างของผลการวัดระดับสายตาในกลุ่มที่ไม่เคยได้รับการตรวจโดยใช้แผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) มาก่อนเมื่อใช้แผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) เทียบกับการใช้แผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ต (SAK charts) แต่พบความแตกต่างของผลการวัดระดับสายตา ในกลุ่มที่เคยได้รับการตรวจมาก่อนเมื่อใช้แผ่นตรวจมาตรฐานชนิดสเนลเลนชาร์ต (Snellen chart) เทียบกับการใช้แผ่นตรวจแบบใหม่ชนิดศักดิ์ชาร์ต (SAK charts)