The Effect of Biometric Parameters on Spot Vision Screener Results

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Abstract

objective: Our aim in this study is to investigate the relationship between biometric parameters and spot vision screener [SVS]

Materyal-Metods: 250 eyes of 125 children between the age of 6,77±1,59 included the study. The results of cyloplegic [CSVS] and noncycloplegic [NSVS] spot vision screener [Plusoptix p12,Germany] measurements and autorefractometer with cycloplegia [CA] were compared. The spherical equivalent [SE] differences of between CA and NSVS measurements with CA and CSVS measurements were compared with AL, ACD, CR, Mean K and AL / CR values. The relationship between them was examined.

Results: According to the amblyopia risk factors [ARFs] based on the criteria from AAPOS 2013 guidelines , 33 eyes [13%] in the NSVS results and 34 eyes [13.6%] in the CSVS results were detected as amblyopic. According to CA results, NSVS had 67.3% sensitivity, 94.5% specificity, CSVS 69.4% sensitivity and 89.1% specificity in detecting amblyopia. When the SE differences of between CA and NSVS values were comparaed with biometric parameters a negative correlation was observed with ACD , AL and especially AL/CR ratio .

Conclussion: Both NSVS and CSVS showed moderate sensitivity and high specificity in detecting AFRs based on the criteria from AAPOS 2013 guidelines. CSVS has no additional clinical advantage. Biometric parameters effect the NSVS results.

Introduction

Amblyopia, unilateral or bilateral, is characterized by low best-corrected visual acuity [BCVA] caused by visual deficiency and/or abnormal binocular interaction without structural defects in the eye or posterior visual pathways [1]. The main causes are strabismus, anisometropia, and deprivation [2]. In the presence of one or more of these causes, the retina cannot form a clear image, resulting in amblyopia in infancy and childhood, when vision develops rapidly [3]. Early diagnosis and treatment can prevent permanent vision loss [4]. Because amblyopia usually causes no symptoms, it can be detected only by screening. Thus, eye examinations are important, especially in early childhood [5]. However, because the accommodation response in children is high, autorefractometer measurements without cycloplegia may give incorrect results [6]. Therefore, measurements using cycloplegia are necessary, but because cooperation and concentration in children are also low, measurement may be difficult. In addition, the side effects of cycloplegic agents are a limiting circumstance [7]. These limitations may be overcome by using spot vision screener [SVS] devices, which are handheld photo refractors that use infrared technology to acquire data from both eyes simultaneously. The greatest advantages of SVS are that it measures quickly and without cycloplegia. Many studies have compared SVS devices with cycloplegia autorefractometers [CA] and retinoscopy [8–11]. SVS sensitivity has been reported as 60.9%-89.8% and its specificity as 70.4%-94.9% [8, 12–14]. However, few studies have investigated factors that may affect

SVS performance [15]. The aim of the present study was to compare SVS measurements made with and without cycloplegia with biometric parameters to identify the factors that may affect SVS performance.

Methods

This prospective comparative study was conducted with the 250 eyes of 125 patients. The study was performed in accordance with the Declaration of Helsinki and was approved by the ethics committee of Fatih Sultan Mehmet Research and Training Hospital, Istanbul, Turkey [Number: 10.12.2020/154]. Written informed consent was obtained from the parents of all patients after they were informed about the study, which excluded patients who could not cooperate with the device, had a history of ocular surgery, congenital cataract, or media opacity, or strabismus or nystagmus.

Initially, all patients were measured using both an autorefractometer [ARK-1a Auto Ref-Keratometer, Nidek, Japan] and an SVS [Plusoptix p12, Germany] without cycloplegia. Then, axial length [AL], anterior chamber depth [ACD], corneal curvature radius [CR], and mean keratometry [meanK] were measured using an optical biometry device [AL-Scan Optical Biometer, Nidek, Japan]. Next, eye drops of 1% cyclopentolate hydrochloride were administered three times at 5-min intervals. After 40 min, the autorefractometer and SVS measurements were repeated. In addition, the patients were given complete ophthalmological examinations.

The study compared patients' spherical values, astigmatism, and spherical equivalents [SE] obtained via cycloplegic refractions of both eyes using the fixed autorefractometer, noncycloplegic SVS [NSVS], and cycloplegic SVS [CSVS].

The data's compliance with normal distribution was tested using the Shapiro Wilk test. The differences among the measurements were analyzed using the Friedman test. Paired comparisons of the parameters that differed were made using Dunn's test. Agreement between the two raters was examined using the Kappa coefficient. A perfect fit was defined as a Kappa value > 0.76, a good fit beyond chance was defined as a value between 0.40 and 0.75, a weak fit beyond chance was defined as a value between 0.00 and 0.39, and no fit as values < zero. The correlation among quantitative variables was examined and interpreted using Spearman's rho correlation coefficient. As descriptive statistics, mean ± standard deviation was used for numerical variables, and median, quarter 1 [Q1], and quarter 3 [Q3] were used for categorical variables, which were given as numbers and values. The SPSS for Windows version 24.0 software program was used for statistical analysis, and $p < 0.05$ was considered statistically significant.

Results

The patients' ages ranged from 5 to 10 years, and the average was 6.77 ± 1.59 years. Of the 250 eyes included in the study, 120 belonged to females and 130 to males [Table 1].

The patients' CA results were as follows: median spherical values, +0.75 [min -3.75, max +8.00]; cylindrical values, +0.25 [min -5.00, max +3.00]; and SE, +0.88 [min -3.88, max +8.50] [Table 2].

The NSVS results were as follows: median spherical values, +0.25 [min -5.00, max +3.25]; cylindrical values, +0.75 [min -0.75, max +4.75]; and SE, +0.38 [min -5.25, max +3.88] [Table 2].

The CSVS results were as follows: median spherical values, +1.00 [min -5.25, max +4.50]; cylindrical values, +0.75 [min +0.25, max +4.50]; and SE, +1.5 [min -1.75, max +4.63] [Table 2].

According to the SE values of the CA measurements, 56 eyes [22.4%] were myopic, 152 [60.8%] were hypermetropic, and 42 [16.8%] were emmetropic. According to the NSVS measurements, 56 eyes [22.4%] were myopic, 111 [44.4%] were hyperopic, and 83 [32.2%] were emmetropic. According to the CSVS measurements, 42 eyes [16.8%] were myopic, 181 [72.4%] were hypermetropic, and 27 [10.8%] were emmetropic. According to the Kappa coefficient, compared with the CA measurements, both the NSVS and CSVS measurements showed excellent fit when detecting myopia, good fit when detecting hyperopia, and poor fit when detecting emmetropia [Table 3].

According to the amblyopia risk factors [ARFs] based on the criteria from AAPOS 2013 guidelines [Table 4], 49 eyes [19%] were detected as amblyopic using the CA results, 33 [13%] were detected using the NSVS results, and 34 [13.6%] were detected using the CSVS results. According to the CA results, NSVS has a sensitivity of 67.3%, specificity of 94.5%, positive predictive value [+PV] of 75%, and negative predictive value [-PV] of 92.2%. Its total accuracy rate was calculated as 89.2%. According to the CA results, CSVS has a sensitivity of 69.4%, specificity of 89.1%, [+PV] of 60.7%, and [-PV] of 92.3%. Its total accuracy rate was calculated as 85.2%.

Mean AL was 22.76 ± 1.1, mean ACD was 3.65 ± 0.3, mean CR was 7.76 ± 0.28, and mean AL/CR was 2.93 ± 0.14 [Table 5].

 When the differences of SE between CA and NSVS values were compared with biometric parameters a negative correlation was observed with ACD , AL and AL/CR ratio [Table 6, Figures 1, 2, and 3].

Discussion

Because amblyopia is a serious condition that can result in permanent vision loss if not treated in childhood, screening programs are recommended [16,17]. Many studies have examined the effectiveness of vision screening tests in preschool children [18–20]. Visual screening in children is also important for early diagnosis of strabismus and other eye diseases besides the serious refractive errors that cause amblyopia. Instrument-based vision scanning has been recommended by the American Association for Pediatric Ophthalmology and Strabismus [AAPOS] and the American Association of Certified Orthoptists [AACO] [21]. Many studies have reported that SVS effectively detects refractive errors and prevents refractive amblyopia in preschool children [22-25].

In the current study, Plusoptix p12 was used as an SVS device. The sensitivity of NSVS in predicting amblyopia was 67.3%, and its specificity was 94.5%. The sensitivity of CSVS was 69.4%, and its

specificity was 89.1%.

Mu et al. compared photo screening and cycloplegic retinoscopy refraction and reported that SVS's sensitivity and specificity for detecting hyperopia were 98.31% and 97.14%, respectively; for detecting myopia, 78.50% and 88.64%, respectively; and for detecting astigmatism, 90.91% and 80.37%, respectively [25].

Paff et al. reported the sensitivity for detecting hyperopia of more than 3.5 D as follows: with the Plusoptix S08, 33.3%; with the Retinomax, 31.0% before cycloplegia and 84.6% after cycloplegia [26].

In another study, Yakar stated that SVS without cycloplegia had 59% sensitivity and 94% specificity for detecting the risk factors of amblyopia compared to the autorefractometer with cycloplegia [15].

In their study of the Plusoptix A09, Yan et al. found that it had an overall sensitivity of 94.9% and a specificity of 67.5% for detecting the risk factors of refractive amblyopia [27]. The differences in these results can be attributed to the different devices used and the different age groups tested.

Although SVS is designed to work without cycloplegia, studies have also compared SVS with autorefractometer and/or retinoscopy and with and without cycloplegia [8]. Yakar noted that sensitivity and negative predictive value increased with cycloplegia. Therefore, he concluded that measurement using cycloplegia may be useful in selected cases [8]. In the present study, despite a slight difference in sensitivity, there was no increase in negative predictive value. This result may be due to the devices used. Nevertheless, we believe that SVS measurement using cycloplegia results in no additional benefit and extends the duration of the procedure, which may be more difficult for the child.

It is known that emetropization occurs with balance among the ocular biometric parameters [28]. Changes in AL and CR are important biometric factors that affect refractive errors [29]. In recent years, studies have noted that the AL/CR ratio is a better marker than AL and CR [30,31]. Therefore, in the present study, we wanted to investigate the potential relationships between SVS and AL/CR, which have never been studied. The only related study in the literature is one by Yakar that compared the performance of SVS with those of ACD and AL without cycloplegia [15]. That study found a negative correlation between them. Our study is only the second to investigate this relationship. In addition, our study compared the CR, meanK, and AL/CR values using SVS both with and without cycloplegia. Like Yakar's study, ours found a negative correlation between ACD , AL, AL/CR ratio when using NSVS, but no correlation when using CSVS.

According to these results, NSVS is less reliable in eyes that have narrow anterior chambers, short axial lengths, and especially reduced AL/CR ratios. Studies have shown that the AL/CR ratio is more than 3 in myopia and less than 2.90 in hyperopia [32,33]. Based on these findings, when measurement using cycloplegia is not possible, SVS values are reliable for myopic children whose AL/CR ratios are 3 or higher.

The strength of the present study is that it compares SVS values both with and without cycloplegia and correlates two conditions with biometric parameters. The study's limitations include its small number of patients and its lack of comparison with retinoscopy.

However, as previously mentioned, studies using SVS have observed different rates of reliability. It is important to know the anatomical factors that may affect NSVS results. To this end, the present study found that NSVS was affected by biometric parameters and had a negative correlation with AL, ACD, and especially the AL/CR ratio.

Based on these results, we conclude that NSVS is more reliable in children who have long axial lengths, deep anterior chambers, and increased AL/CR ratios. We believe that more accurate results will be obtained with larger studies that perform biometry measurements both with and without cycloplegia.

Declarations

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Availability of data and material [data transparency]: 'Not applicable'

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Authors' contributions [optional: please review the submission guidelines from the journal whether statements are mandatory]:

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Meryem Guler Alıs and Abdulkadir Alıs. The first draft of the manuscript was written by Meryem Guler Alıs and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Additional declarations for articles in life science journals that report the results of studies involving humans and/or animals: 'Not applicable'

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Fatih Sultan Mehmet Research and Training Hospital, Istanbul, Turkey [Date 10.12.2020 No:154].

Informed consent was obtained from all individual participants included in the study.

Consent for publication [include appropriate statements] 'Not applicable'

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Tables

Table 1:Demographic Features

Age mean±sd (M)	6,77±1,59 (6)
Gender	
Male	65(%52)
Female	60(%48)

n=250 sd,standard deviation, M, median

Table 2:Reftactive Values

	Min	Median	Mean±sd	Max
CA Spherical	-3,75	0,75	0,85 ±1,82	8,00
CACylindrical	-5,00	0,25	0,04 ±1,30	3,00
CA Aks	,00	90,00	92,88 ±49,43	180,00
CA SE	-3,88	0,88	0,81 ±2,03	8,50
NSVS Spherical	-5,00	0,25	-0,38 ±1,62	3,25
NSVS Cylindrical	-0,75	0,75	0,97 ±0,86	4,75
NSVS Aks	,00	91,00	92,26 ±32,87	178,00
NSVS SE	-5,25	0,38	0,14 ±1,53	3,88
CSVS Spherical	-5,25	1,00	0,68 ±2,07	4,50
CSVS Cylindrical	0,25	0,75	1,10 ±0,89	4,50
CSVS Aks	2,00	92,00	91,30 ±35,06	179,00
CSVS SE	-1,75	1,50	0,49 ±11,33	4,63

sd,standard deviation,

Table 3: Myopia, Hyperopia and Emetropia rates

		n	%	k	P
CA	Myopia	56	22,4		
SVS	Myopia	56	22,4	0,839	<0,001
CSVS	Myopia	42	16,8	0,798	<0,001
CA	Hyperopia	152	60,8		
SVS	Hyperopia	111	44,4	0,539	<0,001
CSVS	Hyperopia	181	72,4	0,601	<0,001
CA	Emetrop	42	16,8		
SVS	Emetrop	83	32,2	0,248	<0,001
CSVS	Emetrop	27	10,8	0,225	<0,001

k:kappa *n=250*

Table 4: Ambliyopia risk factors (2013 AAOPS guideline).

Age,months	Astigmatism	Hyperopia	Anisometropia	Myopia
12-30	>2.0 D	>4.5 D	>2.5 D	>-3.5D
31-48	>2.0 D	>4.0 D	>2.0 D	>-3.0 D
>48	>1.5 D	>3.5 D	>1.5 D	>-1.5 D

D: diopters

Table 5: Biometric Parameters Values

	Min	Max	Mean±sd
AL	20,43	25,19	22,76±1,1
ACD	2,98	5,59	3,65±0,3
Mean K	39,38	47,87	43,52±1,55
CR	7,05	8,57	7,76±0,28
AL/CR	2,52	3,27	2,93±0,14

sd:standard deviation

Table 6 :Correlation Biometric Parameteres with SE Differences

		CA SE- SVS SE	CA SE- CSVS SE
AL	r	**-0,355***	-0,049
	p	<0,001	0,438
ACD	r	**-0,357***	-0,007
	p	<0,001	0,918
Mean K	r	-0,075	0,052
	p	0,240	0,413
CR	r	0,075	-0,052
	p	0,237	0,416
AL/CR	r	**-0,401***	0,059
	p	<0,001	0,351

r: Spearman correlation coefficient * p <0.05
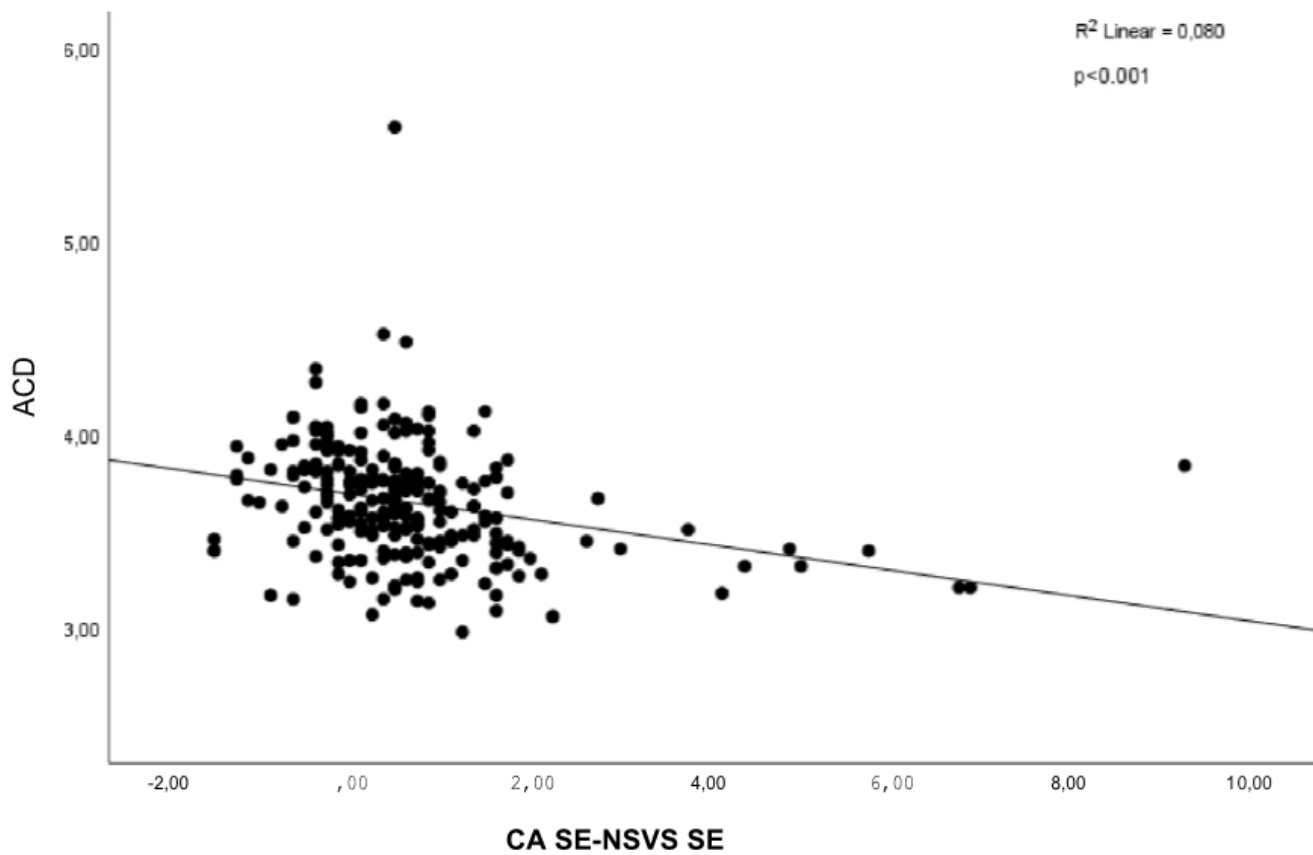
Figures

Figure 1

When the differences of SE between CA and NSVS values were compared with biometric parameters a negative correlation was observed with ACD , AL and AL/CR ratio [Table 6, Figures 1, 2, and 3].
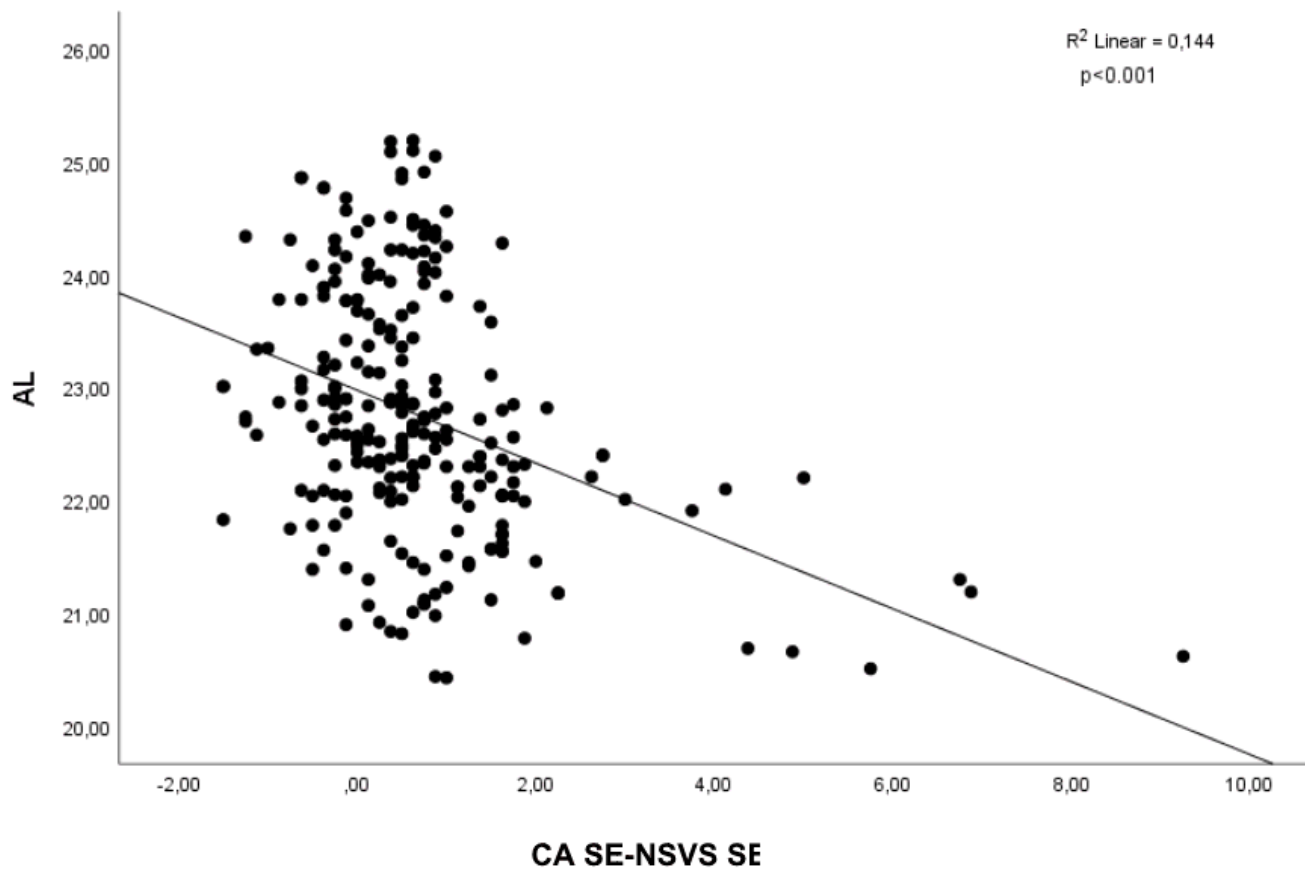
Figure 2

When the differences of SE between CA and NSVS values were compared with biometric parameters a negative correlation was observed with ACD , AL and AL/CR ratio [Table 6, Figures 1, 2, and 3].
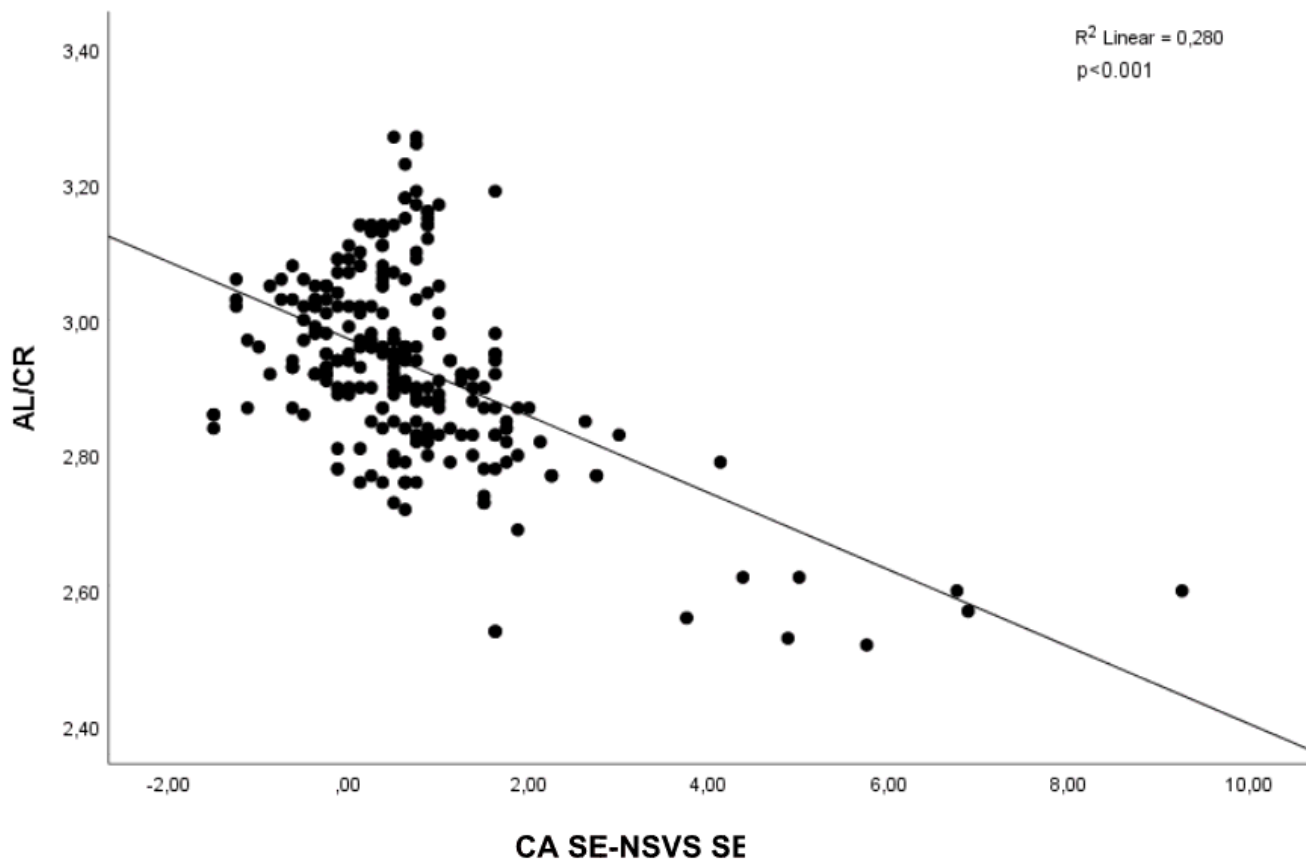
Figure 3

When the differences of SE between CA and NSVS values were compared with biometric parameters a negative correlation was observed with ACD , AL and AL/CR ratio [Table 6, Figures 1, 2, and 3].