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Relationship between dynamic visual acuity and static visual acuity, refractive error, and binocular vision in elite soccer players

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ABSTRACT

Clinical relevance: In many sports, dynamic visual acuity is used. In order to improve dynamic visual acuity, it is important to understand the aspects of the visual system that can cause compromise.
Background: To investigate the parameters of the visual system that may influence dynamic visual acuity in professional soccer players.
Methods: In 2022, 40 professional players were analysed. Screening consisted of a survey, the measurement refractive error, and static and dynamic visual acuity and the binocular vision parameters. All athletes were men with a mean age of 24.9 ± 4.8 years.
Results: The mean refractive error was −0.29 ± 0.61D, and 22.5% of athletes are myopic only and 7.5% hyperopic. Static visual acuity was R: −0.037 ± 0.094 LogMAR , L: −0.036 ± 0.098 LogMAR. Dynamic visual acuity was 0.154 ± 0.118 LogMAR . There is a positive and moderate correlation between monocular static visual acuity and dynamic visual acuity, with $r = 0.524$ ($r^2 = 0.275$, $p < 0.001$) for the right eye and $r = 0.553$ ($r^2 = 0.306$, $p < 0.001$) for the left eye. For the component of astigmatism (J = 0) and for stereopsis in distance vision, the correlation was, $r = -0.472$ ($r^2 = 0.223$, $p = 0.002$) and $r = -0.467$ ($r^2 = 0.218$, $p = 0.002$), respectively.
Conclusion: Athletes with lower static visual acuity in distance vision, or with worse stereopsis in distance vision or more myopic astigmatism, have lower dynamic visual acuity than other athletes.

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Dynamic visual acuity; refractive error; soccer players; sports vision stereopsis

Introduction

Vision is considered the most important sense of human beings. Traditionally, discourse on visual perception has centred on static visual acuity, denoting the aptitude to discern and identify fine details when both the observer and the object remain motionless. However, in the real world, this situation is rare and what happens is that the objects or the observer are almost always in movement, using dynamic (or kinetic) rather than static.

Palidis et al. define dynamic visual acuity as the ability to resolve fine spatial detail in an object that moves relative to the observer.[1] This ability is useful in practically all daily activities, especially in sports, being of particular relevance in ball and motor modalities.[1–3]

Soccer is an example where dynamic visual acuity is required. It is a team sport in which vision plays a fundamental role for the good performance of athletes. Visually, soccer can be characterised as dynamic with sustained performance, involving distance vision, direction location, and visual space recognition.[4]

Although static visual acuity, and consequently, refractive error, is considered the base of the pyramid in the assessment the visual skills of athletes,[5] it is difficult to find relevant information on this topic with regard to elite soccer players. Recently, some studies have been published describing the visual characteristics of elite soccer players in terms of static and dynamic visual acuity, refractive error[2,6,7] and binocular vision.[8,9] These studies have shown that soccer players suffer from the same visual problems as the general population.

Several studies point to static visual acuity, eye movements and the integrity of the retina and processing pathways as being fundamental for dynamic visual acuity, but the literature is neither abundant nor clear with regard to soccer players.[10,11]

Given the lack of information in this area, it seems important to study which factors can affect dynamic visual acuity in elite soccer players. The aim of the study was to investigate which visual system factors influenced dynamic visual acuity in elite soccer players.

Methods

Forty professional soccer players from the Portuguese first league (Primeira Liga) were evaluated. All participants were male. Examinations were conducted by a single experienced optometrist (JJ) in a dedicated room at the training facility of each team. Prior to the evaluation process, a survey was conducted to determine whether the players had undergone any prior eye surgery, including refractive or strabismus surgery, or had suffered from any eye disease or brain concussion.

Distance static visual acuity was assessed using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Players with habitual static visual acuity of 0.00 LogMAR or better and a refractive error between 0.00 and +0.50D underwent binocular vision and accommodative tests using their habitual correction, if they used this and it was up to date. For all other participants, including contact lens wearers, refractive

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error was initially measured by retinoscopy and subsequently by subjective refraction. This refraction was then used to evaluate binocular vision parameters.

Binocular vision assessment included horizontal and vertical phoria at both distance vision and near vision, as well as stereopsis at distance vision and near vision. A cover test was performed to assess for the presence of strabismus. Subsequently, the direction and magnitude of horizontal and vertical ocular alignment were measured using the Modified Thorington Technique. This is a subjective test that enables the measurement of phoric state and exhibits good inter- and intra-examiner repeatability, as well as strong concordance with the cover test.[12,13]

Participants were instructed to fixate on a central fixation light and report the number where the red line intersected the scale. To calculate the mean dissociated phorias, exophorias were assigned negative values, while esophorias were assigned positive values. Vertical phorias were assigned negative values for left eye hyperphoria relative to the right eye, and positive values for right eye hyperphoria relative to the left eye.

Stereopsis for distance vision was measured using COI-Vision Sports software (Centro de Optometría Internacional, Madrid, Spain), while stereopsis for near vision was assessed using the Random dot-S (Vision Assessment Corporation, Illinois, USA) at distances of 5 metres and 40 cm, respectively. The stereopsis values are presented in the classical notation in seconds of arc, but for statistical analysis, they were converted to logarithmic units (logarithm of seconds of arc).[14]

Dynamic visual acuity was assessed using the COI-SV software (Centro de Optometría Internacional, Madrid, Spain) at a distance of 5 metres. A black letter, corresponding to a static visual acuity of 0.00 LogMAR, moved randomly along a curved trajectory on a 56-inch screen at a constant speed of 40 cm/s. The letter size gradually increased until the participant could identify it correctly. The procedure was performed binocularly, and the mean value of three measurements was calculated as dynamic visual acuity score.

Traditional clinical refractive error representations were transformed into vectors using Fourier analysis, as recommended by Thibos.[15] Myopia was defined as $M \le -0.50D$, emmetropia as $M > -0.50D$ and $M < +0.50D$, and hyperopia as $M \ge +0.50D$. For the classification of the refractive error in athletes, only the right eye was used for analyses, while both eyes were utilised for the analysis of visual acuity.

Subjects were stratified by refractive error, dominance (crossed and homonymous), and playing frequency. Regular players were defined as those starting in over 50% of season matches, while sporadic participants exhibited intermittent involvement. These stratifications were utilised in specific analyses to investigate variations in visual parameters among distinct subgroups within the athlete population.

Statistical analysis was performed using SPSS for Windows software (version 28; SPSS, Inc.). Data normality testing was conducted using the Shapiro-Wilk test. The statistical analysis was conducted using parametric tests for mean comparison (t-test for paired and independent samples) and the Pearson correlation coefficient to investigate the correlation between different variables and dynamic visual acuity. Differences were considered statistically significant when the p-value was lower than 0.05.

The study adhered to the principles of the Declaration of Helsinki and was approved by each participating medical department and by the Ethics Subcommittee for Life and Health Sciences of the University of Minho. Informed consent was obtained from each athlete prior to the evaluation process.f

Results

A total of 40 athletes were tested (all men) with a mean age of 24.9 ± 4.8 years (mean±standard deviation). Of these athletes, 52.5% regularly played in the main teams, and 52.5% showed homonymous dominance (dominant eye and dominant foot (or hand, in the case of goalkeepers) on the same side of the body).

Table 1 shows the results for age, static and dynamic visual acuity, refractive error, ametropia, vertical and horizontal phoria at distance vision and near vision and stereopsis at distance vision and near vision. The mean refractive error found for all athletes was −0.29 ± 0.61D, and 22.5% of athletes are myopic only and 7.5% hyperopic. Static visual acuity is similar in both eyes and binocularly, while dynamic visual

Table 1. Demographic results obtained for all sample.

			Mean±SD
Age			24.9 ± 4.8 years
Static visual acuity	Right eye		−0.037 ± 0.094 LogMAR
	Left eye		−0.036 ± 0.098 LogMAR
	Both eye		−0.055 ± 0.071 LogMAR
Dynamic visual acuity			0.154 ± 0.118 LogMAR
Refractive error	M		−0.29 ± 0.61 D
	J0		0.13 ± 0.29 D
	J45		−0.03 ± 0.26 D
Ametropia	Myopia:		22.5%
	Emmetropia:		70.0%
	Hyperopia:		7.5%
Phoria	Distance	Horizontal	−0.4 ± 1.6 Δ
		Vertical	0.0 ± 0.0 Δ
	Near	Horizontal	−1.8 ± 3.3 Δ
		Vertical	0.0 ± 0.0 Δ
Stereopsis	Distance		43.8 ± 8.9 arc sec
	Near		42.7 ± 6.8 arc sec

The ametropia values are proportions of each group (percentage).
Exophorias were considered negative, esophorias as positive.
Vertical phorias were negative for left eye hyperphoria relative to right eye and positive for right eye hyperphoria relative to left eye.
Δ – prismatic dioptre. D – dioptre. arc sec – second of arc.

Table 2. The Pearson correlation coefficient for dynamic visual acuity with other visual system parameters.

			Dynamic visual acuity		
			Correlation coefficient (r)	Determination coefficient (R^2)	Statistical significance (p)
Age			0.077	0.006	0.637
Static visual acuity	Right eye		0.524*	0.275	**<0.001**
	Left eye		0.553*	0.306	**<0.001**
	Both eye		0.309	0.095	0.052
Refractive error	M		−0.133	0.018	0.412
	J0		0.472*	0.223	**0.002**
	J45		0.238	0.057	0.139
Ametropia			−0.150	0,023	0.412
Phoria	Distance	Horizontal	0.053	0,003	0.747
	Near	Horizontal	0.015	0,000	0.928
Stereopsis	Distance		0.467*	0.218	**0.002**
	Near		0.191	0.036	0.237

*Statically significant.

acuity, as expected, is lower than static and is 0.154 ± 0.118 LogMAR.

No vertical phoria were found, and in terms of horizontal phoria there is a slight exophoria in distance and near vision, being −0.4 ± 1.6Δ and −1.8 ± 3.3Δ, respectively. The mean values obtained for stereopsis were 43.8 ± 2.12 sec arc for distance vision and 40.5 ± 1.8 sec arc for near vision.

Table 2 presents the Pearson correlation coefficient for dynamic visual acuity with static visual acuity, refractive error, ametropia, phoria and stereopsis.

A moderate and statistically significant correlation was found between dynamic visual acuity and three other parameters of the visual system.

There is a moderate and positive correlation $r = 0.524$ ($r^2 = 0.275$, $p < 0.001$) for monocular static visual acuity in the right eye and $r = 0.553$ ($r^2 = 0.306$, $p < 0.001$) for the left eye, with dynamic visual acuity. That is, athletes with superior monocular static visual acuity tend to exhibit better dynamic visual acuity (Figure 1).

For the J0 component of astigmatism, and for stereopsis in distance vision, the correlation found was also moderate: $r = 0.472$ ($r^2 = 0.223$, $p = 0.002$) and $r = -0.467$ ($r^2 = 0.218$, $p = 0.002$), respectively. These results show that for higher values of with rule myopic astigmatism the dynamic visual acuity value decreases (Figure 2). In relation to stereopsis, the athletes who present worse results in stereopsis in distance vision also present a decrease in dynamic visual acuity (Figure 3).

No statistically significant differences were found for dynamic visual acuity considering the laterality of the athletes or the frequency of playing in the main team ($p = 0.102$ and $p = 0.406$, respectively).

Discussion

There is a notable focus on examining specific details that might improve the overall performance of soccer players. As a sport of constant movement with frequent changes in direction and speed, it is expected that the visual system as a whole, and dynamic visual acuity in particular, are of paramount importance for its practice.

While dynamic visual acuity has attracted some attention in research on the visual systems of athletes and their connection to sports performance,[16–18] it is not easy to find a standardised method for its assessment and reference values. One notable exception is the work of Quevedo et al., who proposed a valid test for assessing dynamic visual acuity in athletes.[19] The multiplicity of techniques and methodologies used for assessing dynamic visual acuity confounds the analysis and comparison among the various published studies.

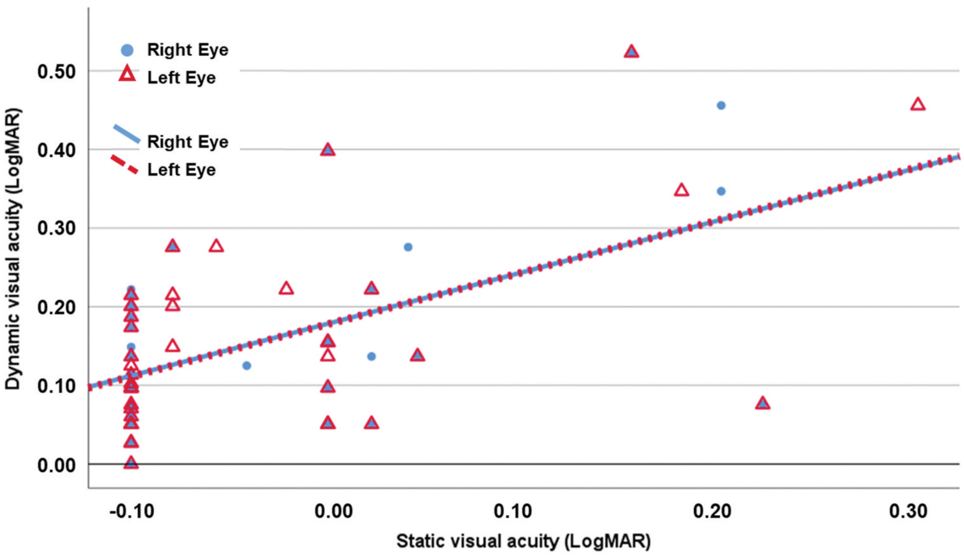

Figure 1. Correlation between dynamic visual acuity and static visual acuity.

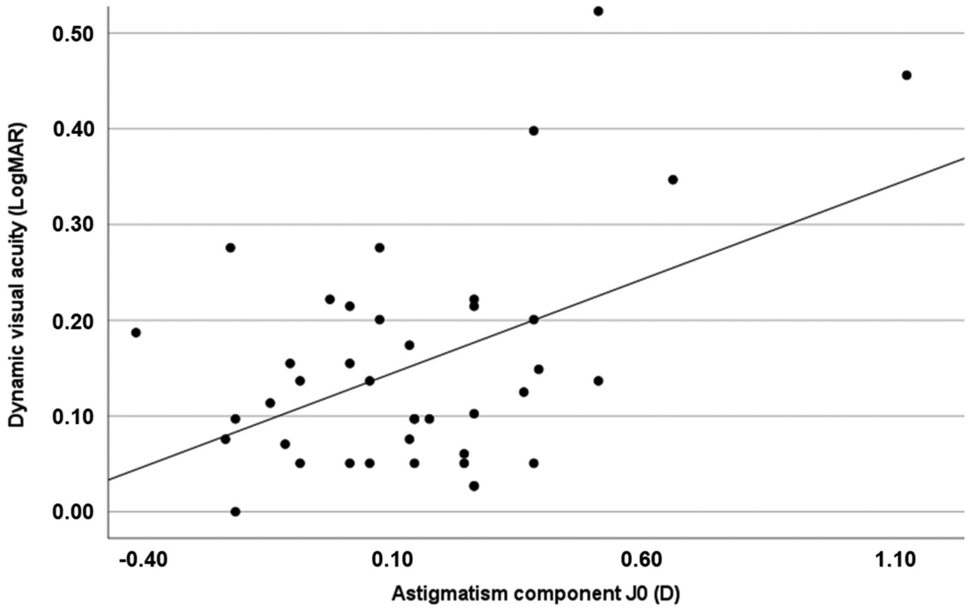

Figure 2. Correlation between dynamic visual acuity and j0 component of astigmatism.

Traditional dynamic visual acuity tests have used targets moving laterally on a screen, on a rotating disc, or using projected letters imaged by rotating mirrors.[5] Today, however, predominantly all tests are computerised, using advanced software and, in some cases, virtual reality.[20,21] In the present study, dynamic visual acuity was assessed by detecting a moving letter on a large-format screen. Despite the diversity of tests and studied populations, the values found in this study are within the same order of magnitude as those reported in other published papers thus far.[2,11,22,23]

A comprehensive examination of the findings related to dynamic visual acuity reveals a statistically significant correlation with monocular static visual acuity, astigmatism, and stereopsis. The dependence of dynamic visual acuity on static visual acuity and blur had already been reported in 2006 by Nakatsuka, et al. In a pilot study conducted with 42 healthy subjects with normal vision, they concluded that dynamic visual acuity was dependent on static visual acuity, and this fact could potentially be related to the blur.[24]

In the current study, a direct correlation was established between monocular static visual acuity of both the right eye ($p < 0.001$) and the left eye ($p < 0.001$) with dynamic visual acuity. However, no such correlation could be established with binocular static visual acuity ($p = 0.052$). One potential explanation for the absence of correlation between binocular static visual acuity and dynamic visual acuity could be attributed to the narrower dispersion of results in binocular static visual acuity compared to monocular.

In the monocular phase, approximately 80% of athletes exhibit visual acuity of 0.00 LogMAR or better, whereas in the binocular phase, this value increases to over 90%. The reduced variability in binocular acuity might contribute to the observed differences. Although a correlation was found, it is considered moderate, as only about 27.5% and 30.6% of dynamic visual acuity values can be explained by the static visual acuity of the right and left eyes.

Recently, Wang, et al., demonstrated that worse binocular dynamic visual acuity was associated with a more significant

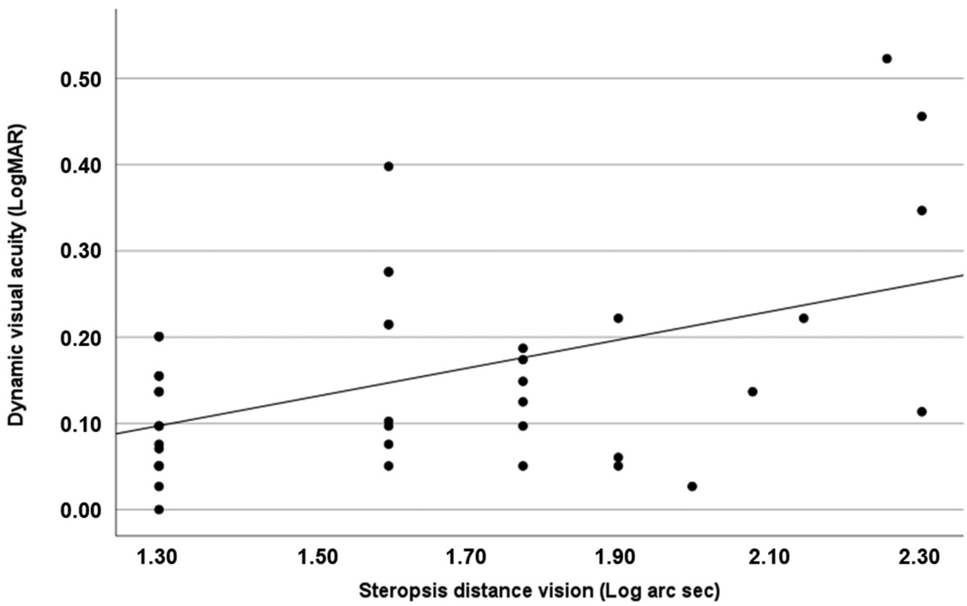

Figure 3. Correlation between dynamic visual acuity and stereopsis in distance vision.

myopic refractive error.[25] In the present study, it was not possible to establish a relationship with myopia; however, a correlation with astigmatism, specifically myopic astigmatism, was identified. No statistically significant relationship between phorias and dynamic visual acuity was observed, yet a significant correlation between stereopsis and dynamic visual acuity was established.

It is not common to find studies that mention the measurement of stereopsis in dynamic visual acuity among athletes, and even less so its relationship with dynamic visual acuity. The present findings indicate that a decline in stereopsis in distance vision is associated with a reduction in dynamic visual acuity among athletes.

The present findings demonstrate a significant association between visual acuity and astigmatic refractive error, corroborating a concept in line with prior observations reported by Erickson.[4] Hatch et al. compiled insights from various authors endorsing the correction of low refractive errors. A substantial decline in tasks involving movement, decision-making, stereopsis, and dynamic visual acuity when encountering myopic defocus values exceeding 1.00D was reported.[26]

Hoshina et al., examined 102 Japanese professional baseball players and observed no discernible differences in dynamic visual acuity across various competitive levels among the athletes.[27] Other authors have failed to find significant differences in performance between elite and sub-elite athletes.[28]

In this study, the sample was divided into two groups: one group of athletes who played regularly, and the other group of athletes who played sporadically. No differences in dynamic visual acuity were found between the two groups. Additionally, no significant differences in dynamic visual acuity were observed between athletes with crossed dominance and those with homonymous dominance.

Despite the large number of publications on vision in athletes, there is a lack of standardised assessment protocols for the visual system tailored to specific sports. These protocols are typically developed based on the clinical experience of examiners, rather than on a solid scientific foundation.[29] The heterogeneity of equipment used and measurement techniques employed further limits the ability to analyse and compare findings across different published studies. Additionally, psychological, motivational, and physical factors can influence the visual performance of athletes, necessitating their consideration when comparing results.[30,31]

Conclusion

This study established the relationship between dynamic visual acuity and static visual acuity, astigmatism, and stereopsis in distance vision. Soccer players with lower static visual acuity in distance vision, worse stereopsis in distance vision, or more myopic astigmatism exhibited lower dynamic visual acuity compared to other soccer players.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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