CLINICAL STUDY

INVESTIGATION OF THE RELATIONSHIP BETWEEN SMARTPHONE USE AND BALANCE AND VISUAL ACUITY PERFORMANCE IN ADULTS

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SUMMARY

Objective: The aim of this study was to examine the negative effects of smartphone use on balance from different perspectives by examining visual acuity skills.

Materials and Methods: Forty-three healthy young adults (29 male, 14 female) were included in this study. It was taken into consideration that the participants included in the study did not have any neurological, vestibular, visual, orthopedic disease history. Sensory Organization Test (SOT), Static Visual Acuity Test (SVA), Minimum Perception Time Test (MPT) and Dynamic Visual Acuity Test (DVA) were applied to the participants via Computerized Dynamic Posturography.

Results: A statistically significant moderate degree correlation was observed between the screen sizes of the participants' smartphones and SOT condition 3 (p=0.02). A statistically significant low-degree correlation was observed between the screen sizes and MPT (p= 0.049). In addition, a statistically significant correlation was observed between the screen sizes and the DVA findings in the up, left roll, and right roll planes (p values; 0.006, 0.04, 0.002, respectively). A statistically significant correlation was observed between the total usage time and the SVA findings (p= 0.006).

Conclusion: Visual acuity skills may be affected by smartphone use. Future studies can document the effects of smartphone use in larger sample groups and in wider age ranges.

Keywords: Smartphone, static visual acuity, dynamic visual acuity, balance

YETİŞKİNLERDE AKILLI TELEFON KULLANIMI İLE DENGE VE GÖRME KESKİNLİĞİ PERFORMANSI ARASINDAKİ İLİŞKİNİN İNCELENMESİ

ÖZET

Amaç: Bu çalışmanın amacı, görme keskinliği becerilerini inceleyerek akıllı telefon kullanımının denge üzerindeki olumsuz etkilerini farklı perspektiflerden incelemektir.

Gereç ve Yöntemler: Bu çalışmaya 43 sağlıklı genç yetişkin (29 erkek, 14 kadın) dahil edildi. Çalışmaya dahil edilen katılımcıların nörolojik, vestibüler, görsel, ortopedik hastalık öyküsünün olmaması dikkate alındı. Katılımcılara Bilgisayarlı Dinamik Postürografi aracılığıyla Duyusal Organizasyon Testi (SOT), Statik Görme Keskinliği Testi (SVA), Minimum Algı Süresi Testi (MPT) ve Dinamik Görme Keskinliği Testi (DVA) uygulandı.

Sonuçlar: Katılımcıların akıllı telefonlarının ekran boyutları ile SOT durumu 3 arasında istatistiksel olarak anlamlı orta dereceli bir korelasyon gözlendi (p=0,02). Toplam kullanım süresi ile SOT durumu 3 arasında istatistiksel olarak anlamlı düşük dereceli bir korelasyon gözlendi (p=0,09). Ekran boyutları ve MPT arasında istatistiksel olarak anlamlı düşük dereceli bir korelasyon gözlemlendi (p= 0,049). Ek olarak, ekran boyutları ile yukarı, sol roll ve sağ roll düzlemlerindeki DVA bulguları arasında istatistiksel olarak anlamlı bir korelasyon gözlemlendi (p değerleri; sırasıyla 0,006, 0,04, 0,002). Toplam kullanım süresi ve SVA bulguları arasında istatistiksel olarak anlamlı bir korelasyon gözlemlendi (p= 0,006).

Sonuç: Görme keskinliği becerileri akıllı telefon kullanımından etkilenebilir. Gelecekteki çalışmalar akıllı telefon kullanımının daha geniş örnek gruplarında ve daha geniş yaş aralıklarında etkilerini belgeleyebilir.

Anahtar Sözcükler: Akıllı telefon, statik görsel keskinlik, dinamik görsel keskinlik, denge

INTRODUCTION

Today, smartphones have become indispensable tools in many areas, such as communication, entertainment, shopping and learning. The evolution of smartphone technology has enabled people to engage in phone calls and various multimedia activities, such as listening to music, watching videos, and gaming, all while on the move. By 2019, approximately 41.5% of the global population used smartphones, reflecting a significant increase in mobile technology adoption worldwide. This growth highlights the role of smartphones as essential tools for communication, entertainment, and accessing digital services[1]. However, studies in the literature show that smartphone use negatively affects balance, walking skills, and the visual system[2,3].

The human balance system receives sensory input from the visual, vestibular, proprioceptive, and auditory systems[4]. A

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Received: 17 January 2025, revised for: 17 March 2025, accepted for publication: 08 April 2025

Cite this article: Orhan E., Altın B., Songül A. Investigation Of The Relationship Between Smartphone Use And Balance And Visual Acuity Performance In Adults. KBB-Forum 2025;24(2):066-073

problem in the cues received from these sensory inputs can negatively affect postural control skills[5]. The visual system does not consist solely of the individual's vision. Gaze stabilization and visual acuity during head movement are important in maintaining the individual's balance. Dynamic visual acuity is the ability of the eyes to detect moving objects, focus them, and quickly adapt to environmental changes[6]. This ability is especially critical for athletes, drivers, and individuals working in busy environments. However, the preservation or weakening of this capacity can also affect an individual's performance in daily life.

Previous studies have examined the ability of individuals to manage different balance conditions during smartphone use[7]. For example, in addition to walking skills, upright posture skills, and fall risk during smartphone use, skills such as eye health and eye strain were also examined[8,9]. Studies have shown that simultaneous smartphone use negatively affects walking and balance skills. In addition, long-term smartphone use can lead to visual function deterioration, especially among young users. Studies in children and young adults have reported increased symptoms such as eye strain, blurred vision, and myopia. A systematic review found that long-term use negatively affects visual function scores[10].

While the above-mentioned skills are examined in the literature, there are limited studies examining dynamic and static visual acuity, which play an important role in maintaining balance. This study aimed to document the long-term effects of smartphone use by examining the relationship between smartphone use and balance and visual acuity skills.

MATERIAL and METHODS

Participants

This study was approved by the ethics committee of Lokman Hekim University (Approval number: 2022/186). Forty-three healthy young adults (29 male, 14 female) were included in this study. It was taken into consideration that the participants included in the study did not have any neurological, vestibular, visual, orthopedic disease history. The demographic informations of the participants were shown in Table 1.

Methods

Sensory Organization Test, Static Visual Acuity Test, Minimum Perception Time Test, and Dynamic Visual Acuity Test were applied to the participants via Computerized Dynamic Posturography (NeuroCom®, Clackamas, OR, USA). The system consists of a patient cabin with dimensions of 135 cm x 155 cm x 239 cm, a mobile and flat platform underfoot, a mobile visual environment with a 15-inch color screen, an overhead support bar, a head movement-sensitive nod sensor, a desktop computer, a 17-inch color screen, and a computer software program.

Sensory Organization Test

During the Sensory Organization Test (SOT), the participant's feet were placed on the platform of the device so that the center of gravity was exactly in the middle. A parachute-type vest was used for the safety of the participants during the test. The balance performance of the individuals was evaluated in 6 different conditions that became progressively more difficult, with 3 trials. The individuals were asked to maintain their upright postural stance in each situation[11,12]. Participants were placed on the platform with their feet shoulder-width apart. Each trial lasts 20 seconds. During each trial, the participant was asked to remain in an upright position without moving as much as possible. It was stated that the visual environment or support surface could move.

Static Visual Acuity Test

The Static Visual Acuity Test (SVA) is an assessment in which the visual acuity of an individual is measured in logMAR while their head is stationary. Participants were placed in a height-adjustable chair 2.5 meters away from the screen so that their eye level was at the same level as the screen[6]. During the test, the individual was asked to correctly state the direction of a specific optotype (the letter "E") while their head was stationary. The optotype (the letter "E") whose aperture randomly faces up, right, down or left gradually decreases in size. The smallest optotype value for which the participant answered at least 3 out of 5 trials correctly was determined in logMAR

Minimum Perception Time Test

The shortest perception time during which an individual can correctly perceive the optotype (letter "E") was determined with the Minimum Perception Time Test (MPT). The optotype size was set 0.2 logMAR above the SVA value. The participant was asked to keep his/her head still and indicate the direction of the optotype he could perceive. The shortest screen time during which the participant answered at least 3 out of 5 trials correctly was determined in milliseconds[13-16].

Dynamic Visual Acuity Test

To measure the speed of head rotation in the Dynamic Visual Acuity Test (DVA), a head movement monitoring device containing a sensor was placed on the participant's head. The participant was asked to move his head at the appropriate speed and angle and to indicate the direction of the optotype he could perceive. The participant was asked to shake his head 20° to the right and 20° to the left at a predetermined speed (85-120 degrees/second) for a total of 40° angles. During the test, feedback was provided to ensure that the participant maintained appropriate head rotation speed. When the correct angle and correct head speed could not be achieved, the system automatically sent a warning screen. When the correct head speed and correct angle were achieved, the participant was automatically given visual feedback by the system. During the dynamic head movement, the smallest value that the participant answered correctly in at least 3 out of 5 trials was determined separately for both right and left directions[6].

Statistical Analysis

The sample size was determined by performing power analysis with 80% power and alpha=0.05 error level. The normality of distribution was assessed by the Shapiro-Wilk test and visually (Histogram, variation coefficient, kurtosis/skewness, detrended plot). The level of statistical significance was set at $p<0.05$. The correlation between the parameters providing normal distribution was analyzed with the Pearson correlation test, while the correlation between the parameters not providing normal distribution was analyzed with the Spearman correlation test.

RESULTS

Descriptive information of the participants was shown in Table 2.

Descriptive information of the participants' MPT, SVA, and DVA findings was shown in Table 3.

No statistically significant correlation was observed between the participants' daily usage time and SOT findings ($p>0.05$). A statistically significant moderate degree correlation was observed between the screen sizes of the participants' smartphones and SOT condition 3 ($p=0.02$). No statistically significant correlation was observed between the screen size and other SOT conditions ($p>0.05$). No statistically significant correlation was observed between the other SOT conditions and total usage time ($p>0.05$). The correlation findings between smartphone usage parameters and SOT conditions were shown in Table 4.

No statistically significant correlation was observed between the daily usage time of the participants and the MPT, SVA, and DVA parameters ($p>0.05$). A statistically significant low-degree correlation was observed between the screen sizes and MPT ($p= 0.049$). In addition, a statistically significant correlation was observed between the screen sizes and the DVA findings in the up, left roll, and right roll planes (p values; 0.006, 0.04, 0.002, respectively). No statistically significant correlation was observed between the other DVA parameters and the screen sizes ($p>0.05$). A statistically significant correlation was observed between the total usage time and the SVA findings ($p= 0.006$). No statistically significant correlation was observed between the screen sizes and the MPT and DVA parameters ($p>0.05$). The correlation findings between the smartphone usage parameters and the MPT, SVA, and DVA parameters were shown in Table 5.

Table 1: Demographic information of participants

	Age	Daily using time (hours)	Screen size (inc)	Total years of use
Mean±SD	25±4	5±1	6±1	8±4
Median	24	5	6	8
Minimum-Maximum	22-37	2-7	3-7	4-19

Daily using time; Daily smartphone usage time of participants, Screen size; Smartphone screen size used by participants

Table 2: Descriptive findings of SOT

	SOT Conditions					
	C1	C2	C3	C4	C5	C6
Mean±sd	92.99±3.06	92.44±2.81	92.13±3.64	84.82±8.15	70.93±7.59	69.45±11.86
Minimum-Maximum	85-97	80-97	86-96	75-93	63-79	56-81
Median	94	93	93	86	71	73

C; SOT condition

Table 3: Descriptive findings of MPT, SVA and DVA tests

	MPT	SVA	DVA					
			Left Horizontal	Right Horizontal	Up	Down	Left Roll	Right Roll
Mean±sd	24±7	0.24±0.05	0.20±0.1	0.24±0.13	0.23±0.12	0.28±0.11	0.25±0.14	0.25±0.13
Minimum-Maximum	16-29	0.19-029	0.18-0.25	0.19-0.27	0.19-0.25	0.26-0.29	0.17-0.27	0.14-0.28
Median	20	0.26	0.23	0.2	0.22	0.28	0.24	0.26

MPT; Minimum perception time, SVA; Static visual acuity, DVA; Dynamic visual acuity

Table 4: Correlations between parameters of smartphone usage and SOT conditions

		SOT Conditions					
		C1	C2	C3	C4	C5	C6
Daily using time (hours)	r	-0.179	-0.076	0.075	-0.009	-0.003	-0.103
	p	0.25	0.62	0.63	0.95	0.98	0.51
Screen size (inch)	r	-0.004	0.036	0.336	0.096	-0.093	-0.117
	p	0.98	0.81	0.02	0.54	0.55	0.45
Total years of use	r	-0.051	-0.131	0.258	0.040	0.081	0.033
	p	0.74	0.40	0.09	0.79	0.60	0.83

C; SOT condition, r; Correlation coefficient, *p<0.05

Table 5: Correlations between parameters of smartphone usage and DVA conditions

				DVA Planes (logMAR)					
		MPT(seconds)	SVA (logMAR)	Left Horizontal	Right Horizontal	Up	Down	Left Roll	Right Roll
Daily using time (hours)	r	-0.073	-0.029	0.046	0.1	0.080	0.126	0.161	-0.050
	p	0.64	0.85	0.77	0.52	0.61	0.42	0.30	0.74
Screen size (inc)	r	-0.302	0.270	-0.224	-0.229	-0.410	- 0.282	- 0.313	-0.459
	p	0.049	0.80	0.14	0.13	0.006*	0.06	0.04*	0.002*
Total years of use	r	-0.107	-0.414	-0.027	0.122	0.084	0.077	0.118	0.206
	p	0.49	0.006*	0.86	0.43	0.59	0.62	0.44	0.185

MPT; Minimum perception time, SVA; Static visual acuity, DVA; Dynamic visual acuity, *p<0.05

DISCUSSION

This study examined the relationship between smartphone usage habits and visual acuity skills, and postural control skills in the presence of different sensory perturbations in young adults.

When the relationship between SOT conditions and smartphone usage subparameters (daily using time, screen size, total years of use) were analyzed, no statistically significant correlation was observed. These findings are consistent with the literature[2]. Because the effect of smartphones on postural control occurs in dual-task conditions. In other words, when individuals use their smartphones simultaneously while continuing their balance tasks in daily life, the impact on their balance skills occurs. In this study, since a simultaneous dual-task condition was not provided, the fact that no significant correlation finding was observed is consistent with the literature and the findings clinically expected[3].

Visual acuity, defined as the ability to distinguish fine details, is defined and measures the resolution capacity of the visual system and plays an important role in providing detailed visual perception[17]. Static and dynamic visual acuity, and Minimum perception time parameters were used to evaluate visual acuity in our study.

Static visual acuity (SVA) test provides a measure that reflects individuals' performance against stationary stimuli during eye movements and is directly related to ocular resolution[18]. In contrast, dynamic visual acuity (DVA) evaluates the resolution and spatial discrimination capacity of the visual system over moving stimuli. DVA is considered an important functional parameter We evaluated if there were decrements in visual acuity during head movements and compared the DVA results with smartphone usage time. Our study results show that there is no decrement in the visual acuity of our subject. One of the important matters to discuss is the relationship between smartphone use and dry eye disease. Dry eye disease is a very common disease and negatively affects the quality of life by causing eye discomfort, fatigue, and visual impairment[19-21]. This situation is becoming more common in the elderly population as well as in young individuals who use digital devices extensively[22]. Inomata et al reported that long-term use of digital devices causes dry eye symptoms to occur more frequently, especially in individuals who spend more than 8 hours per day on screens. It is stated that the younger age group may be more susceptible to dry eye disease, and this situation has become more evident due to increased use of digital devices. These findings reveal that young individuals interacting with more digital screens may have negative effects on eye health[21].

Research shows that DVA performance of the men is generally higher than the women. This difference suggests that men's superiority in DVA is due to educational and behavioral factors rather than an innate trait[23,24]. This outcome is contrary to that of Quevedo et al. Who found no differences between the genders in the study with the young athletes[25]. When the participants' MPT, SVA, and DVA findings were examined, it was observed that they were within the normative ranges in the literature. In other words, even though it was observed that smartphone use had a statistically significant effect on some of the visual acuity sub-parameters, the findings were still considered to be within the normative range in our study.

In a clinical context, the decline in static visual acuity associated with increased total smartphone usage time does not hold standalone clinical significance from a vestibular perspective. This suggests that while prolonged smartphone use may lead to subtle changes in visual acuity, these alterations may not necessarily indicate vestibular dysfunction on their own.

However, as smartphone screen sizes increase, the reduction in dynamic visual acuity, particularly in the vertical and roll planes, raises important considerations. The observed changes in these planes suggest that screen size may influence oculomotor and vestibular interactions. Nevertheless, for these findings to be clinically interpreted with confidence, further studies with larger sample sizes are required. A more extensive dataset would help establish clearer values and determine whether these effects have practical clinical implications, particularly in populations with preexisting vestibular or oculomotor disorders.

It is known that DVA deteriorates with age and that this deterioration begins earlier than SVA. With aging, especially losses in retinal sensitivity and physiological changes in eye movements negatively affect DVA. This decrease, which begins after the 20s, shows a significant decline in the 70s[23,24]. This decrease becomes more noticeable not only due to speed and resolution, but also due to the delay and inefficiency in the tracking movements of the eyes[26]. Since this difference could be a confounding factor, and hard to eliminate the age effect, only young adults were included in our study.

Limitations and Future Studies

Our hypothesis aimed to examine the long-term effects of smartphone use on balance and visual acuity performances through a correlational approach. However, this study does not incorporate a dual-task paradigm in its methodology.

One of the limitations of this study is that it focuses solely on healthy young adults. Future research should examine the impact of smartphone use on balance and visual acuity in different age groups and various patient populations to provide a broader understanding of its effects.

Additionally, while this study did not employ a dual-task paradigm, future studies could benefit from integrating such an approach. Assessing balance skills while using a smartphone could provide more comprehensive insights into its real-world implications on postural control and cognitive-motor interactions.

Financial and technical support: No financial and/or technical support was received for this study.

Conflict of interest: There is no conflict of interest.

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