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ORIGINAL RESEARCH

Relationship of hand-eye reaction time with stereopsis in 15-19-year-old adolescents

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Abstract

The aim of this study was to investigate the relationship between hand-eye reaction time and stereopsis in adolescents aged 15-19. A total of 150 participants (70 males, 80 females) with an average age of 16.76±1.21 years participated in the study. First, hand-eye reaction time measurements were taken from the participants. Then, the stereo fly test was performed, and stereopsis values were recorded. A statistically positive and moderately significant relationship was detected between hand-eye reaction time and stereopsis. A statistically positive and moderately significant relationship was found between hand-eye reaction time and stereopsis in adolescent males. There was a statistically positive and low significant relationship between hand-eye reaction time and stereopsis in adolescent females. In conclusion, this study examined the relationship between hand-eye reaction time and stereopsis in adolescents aged 15-19 years and revealed that there is a link. These results support that depth perception plays a role in adolescents' motor skills and performance in daily activities.

Introduction

When people fulfill their basic activities in daily life, their quick reaction to their environment makes them feel safe. Reaction is defined as the human response (motoric phase) to an external stimulus (perceptual phase) (Magill & Anderson, 2010). Reaction time, or response time, is a term that refers to the time between the perception of a sensory stimulus and the initiation of a movement response (Balkó et al., 2016). Hand-eye reaction time is considered an indicator of the cognitive system's ability to process information (Spierer et al., 2010).

When it comes to reaction time, we can divide it into two. These can be divided into simple reaction time and selective reaction time. Simple reaction time is usually defined as the time it takes for an observer to perceive a presented stimulus, for example, a sound or light signal. Selective reaction time, on the other hand, involves the decision process in which a person has to choose one correct response among many stimuli (Żak et al., 2023). When hand-eye reaction time is observed concerning age, it can be stated that it decreases rapidly from childhood to adolescence and gradually increases until old age (Dykiert et al., 2012; Bucsuházy & Semela, 2017).

Depth perception, or stereopsis, is primarily a central processing task in the visual system (Cumming, 2002), whereas hand-eye reaction time involves sensory input, information processing, and motor output (Salthouse, 2007). Stereopsis (also known as binocular depth perception) influences sports performance to a great extent. Stereopsis is traditionally considered a measure of how well an individual can interpret binocular disparity as perceived depth by determining the spatial correlation of points projected onto the retina (O'connor & Tidbury, 2018). Stereopsis is a three-dimensional analysis of the environment. It is a visual skill that allows individuals to perceive the distance between objects, evaluate spatial speed, and perceive the size of objects. Technically calculated in arc seconds, stereopsis represents the minimum distance at which depth perception is possible (Presta et al., 2021).

Monocular and binocular cues are required to determine the change in depth as a physical object approaches or moves away from an individual. Each point that prevents fixation provides a cross disparity, meaning that these points are projected onto the

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temporal retina of both eyes. This is a binocular disparity because the point corresponding to the temporal retina of one eye is the nasal point of the other eye. This enhanced visual function based on binocular disparity is particularly important in skill-specific sports (Heinen & Vinken 2011).

Stereopsis is one of the essential visual skills used in daily life, including reading, writing, walking, driving, physical activity, etc., and its impairment adversely affects interaction with subjects or objects (O'connor et al., 2010; O'connor & Tidbury, 2018). However, high stereopsis supports many movements, including motor behaviors (O'connor et al., 2010).

The aim of this study was to examine the relationship between hand-eye reaction time and stereopsis, or depth perception, in adolescents aged 15-19. There are limited studies in the literature on the relationship between stereopsis and reaction time. Investigating this relationship may help address existing gaps and contribute to the discovery of new application areas. The findings of this research could significantly contribute to the design of educational and adaptation programs aimed at supporting the development of visual perception and motor skills in young individuals. Furthermore, identifying the relationships between stereopsis and hand-eye reaction time could provide valuable insights in areas where reaction time is crucial, such as driving safety and sports performance. It is also believed that this research could make significant contributions to various fields, including virtual reality and simulation technologies. In connection with this relationship, better analysis of visual information processing data could aid in the development of new methods, particularly in visual-motor coordination training. In this context, the study aims to make significant contributions not only to theoretical knowledge but also to practical applications by focusing on outcomes that are applicable in daily life.

Methods

Participants

A total of 150 participants (70 males, 80 females) with a mean age of 16.76±1.21 years, who were high school students in Konya province, voluntarily participated in the study. Participants were selected from students who had engaged in sports in at least one discipline during their school years. Before the study, the participants were provided with detailed information about the research topic and measurement methods. Participants aged 18 years and over were asked to read and sign the informed consent form, and for participants under 18 years of age, their parents/guardians were asked to sign the relevant form. After obtaining the necessary permissions for the participants, it was reported that they did not have any health problems that would prevent them from being included in the study. The research was approved by the Ethics Committee of Selcuk University, Faculty of Sport Sciences (Approval Date: 04.04.2024, Approval no: 37).

Implementation

All participants were first informed about the measurements to be made. Before the hand-eye reaction time measurements were taken, the participants were given the opportunity to make a tryout to get used to the measurement tool.

Hand-Eye Reaction Time

BlazePod™ (New Zealand) exercise and training kit was used to measure hand-eye reaction time. This system is a wireless system consisting of a different number of lighted disks (pods) used for the detection and development of participants' hand-eye reaction times, quickness, speed, etc. performances and can be controlled from a smartphone. “Formula Reactions” in the smartphone application is a protocol that measures hand-eye reaction time. Based on this protocol, with the help of a vacuum apparatus, 4 lighted disks were placed on the wall in a square shape at 1.5m intervals and the 5th disk was placed in the middle of the 4 disks. Each of the 5 disks gives a signal independently of each other. It is a measurement method based on the participant disabling the disk by touching the signaling disk. For 30 seconds, the time it takes to switch off the signaling disk by touching it as soon as possible is recorded as reaction time (Aslan et al., 2023).

Each participant was instructed to complete the test protocol by touching the illuminated disk with both hands as soon as possible during the 30-second test, which started with the command given by the application while waiting, facing the wall where the disks were placed. The best value after two trials, the average duration of total touches within 30 seconds was recorded as the participant's hand-eye reaction time in milliseconds.

Stereo Fly Test

The stereopsis measurements of the athletes were measured with the “Stereo Fly Test” (Stereo Fly Test Stereo Optical CO Inc). In this test, fine stereopsis is measured. It is suitable for adults as it provides a precise

rating of the stereopsis value expressed in arc seconds. The athletes were allowed to participate in the test wearing polarized glasses. In the test, there are sets with a difference in one of the four circles, which causes depth perception by providing cross disparity in the image when viewed through polarized glasses (Gawęcki, 2019).

Participants were asked to identify three-dimensional circles and the arc seconds corresponding to the correct answers were recorded as the stereopsis value. The correct responses given by the participants in the stereopsis test are expressed in the test key as values ranging from 40 arc seconds to 800 arc seconds.

Data Analysis

The study data were summarized as average and standard error. Normality distributions were tested with the Shapiro-Wilk test. Spearson correlation analysis and regression analysis tests were applied according to the results of normality values. The significance level was considered as 0.05. SPSS 26.0 package program was used for all statistical analyses.

Results

Table 1 presents the mean and standard deviation of age, height, body weight, and BMI values for male and female participants.

Table 1

Descriptive characteristics of the participants.

	Gender	Mean	Std. Dev.
Age (years)	Male	16.57	.16
	Female	16.92	.19
Height (cm)	Male	180	1.43
	Female	163.35	.93
Body Weight (kg)	Male	67	1.47
	Female	55.47	1.03
BMI (kg/m^2)	Male	20.60	.35
	Female	20.74	.09

Table 2 demonstrates the average and standard deviation values of hand-eye reaction times and stereopsis test measurement results.

As shown in Table 3, female participants a statistically positive and moderately significant relationship was found between hand-eye reaction time and stereopsis (r=.362; p=.00). Male participants a statistically positive and moderately significant relationship was found between hand-eye reaction time and stereopsis (r=.496; p=.00). In all participants, there was a statistically positive, low-level significant relationship between hand-eye reaction time and stereopsis (r=.246; p=.00).

Table 2

Mean and standard deviation values for hand-eye reaction time and stereopsis.

	Gender	Mean	Std. Dev.
Hand-eye reaction time (ms)	Male	632.17	8.43
	Female	759.11	6.79
	Total	699.87	7.44
Stereopsis (Depth Perception) (arc/sec)	Male	101.14	14.86
	Female	107.75	10.86
	Total	104.67	9.00

Table 3

Descriptive characteristics of all participants and correlation analysis between hand-eye reaction time and stereopsis values.

Variables	Participants		Stereopsis
Hand-eye reaction time	Women	r	.246**
		p	.028
	Man	r	.496**
		p	,00
	Total	r	.362**
		p	.000

** p < 0.05*

It is observed that there is a low-level and positively significant relationship between hand-eye reaction time and stereopsis values of all participants (R: .281, R2: .079, p: 0.012) and hand-eye reaction time explains 7.9% of the total variance. In other words, a 7.9% change in the dependent variable (hand-eye reaction time) is explained by the independent variable (stereopsis) included in the model (Table 4).

It is found that there is a moderate and positively significant relationship between hand-eye reaction time and stereopsis values of all participants (R: .300, R2: .090, p: 0.012) and hand-eye reaction time explains 9% of the total variance. That is, a 9% change in the dependent variable (hand-eye reaction time) is explained by the independent variable (stereopsis) included in the model (Table 5).

Table 4

Regression analysis for stereopsis values of hand-eye reaction time for female participants.

Variables	B	Std. Error	β	t	p
Fixed	740.187	9.826	-	75.330	.000
Stereopsis	.176	.068	.281	2.586	.012

Dependent Variable: Hand-eye reaction time.
R: .281; R^2: .079; F: 6.690; p: 0.012
** p < 0.05*

Table 5

Regression analysis for stereopsis values of hand-eye reaction time for male participants.

Variables	B	Std. Error	β	t	p
Fixed Stereopsis	614.934	10.473	-	58.719	.000
	.170	.066	.300	2.596	.012

Dependent Variable: Hand-eye reaction time.
R: .300; R^2: .090; F: 6.741; p: 0.012
** p < 0.05*

Table 6

Regression analysis for stereopsis values of hand-eye reaction time for all participants.

Variables	B	Std. Error	β	t	p
Fixed Stereopsis	680.020	10.027	-	67.819	.000
	.190	.066	.230	2.872	.005

Dependent Variable: Hand-eye reaction time
R: .230; R^2: .053; F: 8.247; p: 0.005
** p < 0.05*

There is a low level and positively significant relationship between hand-eye reaction time and stereopsis values of all participants (R: .230, R2: .053, p: 0.005), and hand-eye reaction time explains 5.3% of the total variance. In other words, a 5.3% change in the dependent variable (hand-eye reaction time) is explained by the independent variable (stereopsis) included in the model (Table 6).

Discussion

When the literature was analyzed, it was noted that there was not much research on the relationship between hand-eye reaction time and stereopsis. The relationship between hand-eye reaction time and stereopsis is crucial as it is a significant determinant of the speed and accuracy of visual information processing. Therefore, understanding the relationship between these two factors is of great importance for a better understanding of visual information processing processes. Abernethy (1986) defined the visual mechanism in humans as the cognitive differences that people need for the analysis, selection and presentation of information in both sportive skills and daily life.

The brain combines the images from each eye to create a three-dimensional picture that indicates whether an object is near or far away. This skill leads individuals to perceive images in three dimensions and is called stereopsis (Millard et al., 2023). Stereopsis is one of the fastest visual depth cues that have been shown to increase the learning effect in grasping an object and the performance of fine motor skills (Paulus et al., 2014). Zaroff et al. (2003) compared stereopsis values between males and females across a wide age range of subjects (15 to 79 years) and revealed no statistically significant gender differences in age-related effects. Similarly, according to the results obtained in this study, no significant difference was observed in the stereopsis test results of males and females due to the gender factor.

Hand-eye coordination refers to the ability of the hands and eyes to work as a whole. Hand-eye coordination is the ability to determine how fast a person will physically react after seeing an object such

as a ball and the ability to direct their hands, feet and body to the right place in order to react (Millard et al., 2023). The resulting hand-eye reaction time is defined as the time from the perception of a stimulus to the reaction given as a result of that stimulus (Huerta Ojeda, 2022). Considering the gender factor, it has been observed that although muscle contraction rates are the same in males and females, the reaction time is shorter in males (Payne & Isaacs, 2002). In accordance with this information, hand-eye reaction times were found to be shorter in males in this study.

In a study conducted on 450 baseball athletes, it was revealed that athletes with good hand-eye reaction time had better batting performances (Laby et al., 2018). In another study, it was observed that table tennis players had better hand-eye reaction time than non-players (Lee et al., 2021). Studies usually examine the relationship between hand-eye reaction time and stereopsis with the determined performances. In a study conducted on elite volleyball players, the relationship between visual skills and volleyball spiking and ball reception performances was examined and it was reported that stereopsis had a significant effect on both spiking and ball reception performance (Aslan, 2023). In addition, Lee et al. (2021) conducted a study on table tennis athletes and university students and found no significant relationship between reaction time and stereopsis. Stereopsis has a central function in visual mechanisms (Cumming, 2002), whereas hand-eye reaction time involves sensory input, information processing, and motor output (Salthouse, 2007). Moreover, stereopsis is essential in dynamic situations requiring rapid visual skills (Bauer et al., 2001).

In this study, a significant positive relationship was found between hand-eye reaction times and stereopsis in all participants. After a detailed analysis according to the gender factor, it was observed that the same relationship persisted for both males and females. According to the results of the regression analysis applied to determine the size of the relationship, stereopsis had an effect of 5.3% on hand-eye reaction time when all participants were considered, while this rate was found to be 9% for males and 7.3% for females. It is known that males have better reaction times than females (Bamne et al., 2011; Woods et al., 2015). It is thought that the higher rate in men is due to this difference. There have not been many studies conducted on this subject in the literature.

This relationship between hand-eye coordination and stereopsis provides an important finding in terms of the development of motor skills and visual perception of adolescents. The results emphasize the importance of assessing visual abilities and motor skills together. Understanding this relationship in adolescents is an important source of information for educators, health professionals, and coaches, and it is thought to contribute to the determination of strategies to develop the potential of adolescents in these areas.

In conclusion, this study examined the relationship between hand-eye reaction time and stereopsis in 15-19-year-old adolescents and presented that there is a link. These results support that depth perception plays a role in adolescents' motor skills and performance in daily activities. Training and exercise programs that support the development of depth perception may contribute to improved performance by improving hand-eye reaction time. Furthermore, educational institutions and sports clubs can organize stereopsis-oriented activities and trainings to improve adolescents' motor skills.

However, the limitations of our study should also be taken into consideration. The fact that our research sample is limited to a certain age group and demographic characteristics limits the generalizability of the results. In future studies, it is anticipated that conducting studies with different age groups and more participants will provide more detailed information about this relationship.

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