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Original Article

Comparison of Balance and Proprioception in Individuals with Myopia Compared to Healthy Peers

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ABSTRACT

Objective: The visual system is one of the 3 most essential systems for maintaining balance. However, the evaluation of refractive error such as myopia has always been neglected in balance studies. This paper aimed to examine the differences in balance and proprioception measurements between individuals with myopia and their healthy peers.

Materials and Methods: Fifteen subjects with myopic eye defects and 15 healthy peers were included in the study. Balance evaluations consisted of the tandem walk test (TWT), the limits of stability test (LOS), and the modified clinical test of sensory interaction and balance (mCTSIB). These evaluations were performed with a computer-aided NeuroCom Balance Master device. Additionally, proprioception was measured with the Biodex System 3 isokinetic dynamometer.

Results: Individuals with myopic defects had higher step widths ($P = .001$), and end-sway ($P = .007$) than their healthy peers. The reaction time, maximum excursion, and directional control values of the myopia group were lower than those of the healthy peer group, but there was no difference between the results of the LOS and the m-CTSIB tests ($P > .05$ for all parameters). Moreover, the 60° proprioception evaluation deviation was higher in the myopia group for both dominant and non-dominant extremities. However, this deviation was not statistically significant ($P > .05$).

Conclusion: This study showed some differences in the measured values for balance in myopic individuals compared to healthy peers. We think that the evaluation of the participants with the orthoses they use will provide more accurate results from the measurements in future studies evaluating balance and proprioception.

Keywords: Balance, myopia, proprioception, refractive error

Introduction

The World Health Organization defines visual impairment as a reduction or limitation of visual acuity in the visual field, and it causes a decrease in balance reactions and loss of function in the everyday activities of in young adults.[1-3] Improving balance skills prevents functional losses resulting from disturbances in balance reactions and impairments in daily-life activities.[3] A normal balance control can only be achieved by fully integrating information from the visual, vestibular, and somatosensory systems.[4] Deteriorated information from any of these systems results in a decrease in balance and proprioception.[5-7] Thus, visual impairments are significant in terms of balance and proprioception.

The visual system allows the body to perceive its position in space. Proprioception is the most important component of balance and postural control, and is defined as the ability to perceive the location in space without visual feedback.[8] It is possible to come across studies in the literature stating that deterioration in visual acuity causes an increase in musculoskeletal complaints and postural sway and a decrease in physical activity levels in young adults.[9,10] In a study, it has been reported that visual impairment negatively affects balance and proprioception, regardless of musculoskeletal complaints and age in elderly individuals.[11] However, such studies were conducted with patients who had visual impairments due to congenital, traumatic, or systematic diseases, rather than refractive errors.

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Myopia is one of the most common refractive errors, and its prevalence is approximately 34% in individuals under the age of 40.[12,13] Another refractive error is hyperopia. Although there are studies that evaluate the effect of hyperopia on falling and loss of balance, there are not enough clinical evaluation studies about myopia.[14]

The number of individuals with myopic vision defects increases every day due to different factors such as genetic predisposition, family history of myopia, and level of education. Therefore, it is essential to examine the effect of myopia on balance and proprioception. However, there are few studies on this issue. Therefore, this study aims to compare the differences in the balance and proprioceptive senses of individuals with uncorrected myopic vision defects, compared to their healthy peers.

Materials and Methods

Participants

This study involved 30 participants who met the inclusion and exclusion criteria. The inclusion criteria were: (1) being diagnosed with mild myopia; (2) astigmatism <0.75 diopters; (3) not having any refractive error for the healthy control group; and (4) age between 18 and 40 years. The exclusion criteria were (1) diagnosed with vestibular dysfunction; (2) having a history of vestibular neuritis; (3) diagnosed with benign paroxysmal positional vertigo; (4) having a history and complaint of recurrent dizziness; (5) having had any injury or surgery in the lower extremity earlier; (5) having hyperopia; and (6) being in the menstrual period. Evaluations were made under the supervision of a specialist physiotherapist.

The ethics approval was obtained from the Marmara University Faculty of Health Sciences Ethics Committee for Non-Invasive Clinical Studies, with protocol number 03.01.2019/13. The study was conducted according to the principles of the Declaration of Helsinki and informed consent was obtained from the participants. The rules of research and publication ethics were followed in the study.

Sociodemographic Data

The participants completed the form that consisted of information about age, gender, height, weight, dominant extremity, vision defect, the auxiliary device, and duration of the visual deficiency.

Balance Evaluation

The sense of balance was evaluated with a computer-assisted NeuroCom Balance Master (NeuroCom. International Inc., Clackamas, Ore, USA). The tests applied were the TWT, the LOS test, and the mCTSIB. All participants were asked to perform the tests without wearing glasses or contact lenses.

Tandem Walking Test (TWT)

The participant was asked to walk as quickly as possible, placing one foot in front of the other. At the end of the line, the participant stopped and maintained this position for 5 seconds. The step width, speed, and end-sway were measured.[15]

Limits of Stability (LOS)

In this test, there are 8 different targets on the circle. Each target moves clockwise and is tested sequentially. There is a 45° angle between each target. The evaluator told the patient to achieve targets by transferring their center of gravity without lifting their heels off the platform. After the test, the reaction time (RT), maximum velocity (MVL), maximum excursion (MXE), endpoint excursion (EPE), and directional control (DCL) were measured.[16]

Modified Clinical Test of Sensory Interaction and Balance Test (m-CTSIB)

The ankle strategy is considered with 4 different methods in the test: firm surface, eyes open; firm surface, eyes closed; foam surface, eyes open; and foam surface, eyes closed. During the test, the participant tried to stand constantly for 30 seconds. The participants were asked to stand upright for 30 seconds. Ten-second breaks were given between each test.[17]

Proprioception Evaluation

Proprioception was evaluated with the Biodex System 3 isokinetic dynamometer (Biodex Medical Inc., Shirley, NY, USA). The participants were seated in the dynamometer chair such that the hip and the knee were at a 90° angle. The trunk and thighs were also fixed with straps to prevent other movements could that disrupt the objectivity. The center of the dynamometer was aligned according to femoral lateral epicondyles. Proprioception measurements were made with the knee flexed at 30°, 60°, and 90°, separately. The knee was positioned to full extension before each angle was taught to the patient. Firstly, a 30° knee flexion angle was taught to the participant with their eyes open. Then the participant brought their foot to the starting position and was asked to arrive at the same angle with their eyes closed. This test was repeated 3 times, and the averages of repetitions were calculated. The same protocol was repeated for the 60° and 90°. Measurements were performed bilaterally.[18]

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) (v. 11) package program was used in the statistical analysis. Since the data show the normal distribution, the mean and standard deviation values were used. The independent samples *t*-test was used for intergroup analysis. The statistical significance level was accepted as 5%. The post hoc power of the study was calculated with G*Power 3.1.9.7 software and the calculations were based on the TWT results, which are the primary outcomes. According to the results, the power of the study was 97.04%.

Results

The mean age, height, and weight of the myopic participants were 21.13 ± 2.41 years, 171.00 ± 9.43 cm, and 65.93 ± 11.90 kg, respectively. These values were 22.40 ± 1.35 years, 174.66 ± 8.59 cm, and 67.53 ± 13.38 kg, respectively, in the healthy group. The age, height, and weight of the participants were similar ($P > .05$). Also, the mean degree of myopia was 1.86 ± 0.95 in the right eye, and 1.98 ± 0.78 in the left eye; the duration of myopia was 7.93 ± 3.17 years. While 43.3% of the myopic group consisted of females, 33.3% of the healthy group was female. All of the participants were right-handed and 66.7% of the myopic patients were using glasses. The demographics and clinical characteristics of the participants are shown in Table 1.

In the TWT results, it was seen that the step widths, speed, and end-sway of the myopic group were affected more than the healthy group. However, this efficiency was significant only in step width ($P = .001$), and speed ($P = .007$), Moreover, no statistically significant difference was observed in any sub-parameters of LOS and mCTSIB tests ($P > .05$). Although the movement speed and direction control values were not statistically significant, they were lower than those of the healthy group. All results of the balance assessments are shown in Table 2.

According to the results of the proprioception tests, the deviation from the target angle of the dominant and non-dominant extremities was generally lower in the myopia group. However, this difference

Table 1. Demographic Characteristics of Participants

Parameters	Myopic, Mean (SD)	Healthy, Mean (SD)	*P*
Age	21.13 (2.41)	22.40 (1.35)	.052
Height	171.00 (9.43)	174.66 (8.59)	.280
Weight	65.93 (11.90)	67.53 (13.38)	.901
Myopic degree (right)	1.86 (0.95)	-	-
Myopic degree (left)	1.98 (0.78)	-	-
Myopic duration (years)	7.93 (3.17)	-	-
	n (%)	n (%)	
Gender			
Female	8 (43.3)	5 (33.3)	-
Male	7 (56.7)	10 (66.7)	-
Dominant extremity			
Right	15 (100)	15 (100)	-
Use of glasses			
Yes	10 (66.7)		-
No	5 (33.3)		-

SD, standard deviation.

between the groups was not statistically significant. All values are shown in Table 3.

Discussion

Our study is one of the few studies investigating the effect of refractive error on balance and proprioception. According to the results, individuals with mild myopia have higher step widths and sway speed than healthy individuals. In addition, although the reaction times and direction control of individuals with myopia were lower than their healthy peers, this difference was not statistically significant. The proprioception values measured by the isokinetic dynamometer did not have a statistically significant difference, similar to the results of the balance parameters.

Table 2. Results of Balance Parameters Between Groups

Test	Subtitle	Groups	Mean (SD)	*P*
Tandem walk test	Step width (cm)	Myopic	13.60 (6.54)	**.001***
		Healthy	6.65 (1.67)	
	Speed (cm/s)	Myopic	25.11 (5.17)	.146
		Healthy	21.62 (7.40)	
	End-sway (°/s)	Myopic	7.58 (4.19)	**.007***
		Healthy	4.24 (1.51)	
Limits of stability	Reaction time (s)	Myopic	0.73 (0.23)	.349
		Healthy	0.80 (0.17)	
	Movement velocity (°/s)	Myopic	4.80 (1.16)	.056
		Healthy	4.05 (0.87)	
	Endpoint excursions (%)	Myopic	80.93 (7.13)	.719
		Healthy	79.73 (10.61)	
	Maximum excursions (%)	Myopic	93.86 (4.25)	.122
		Healthy	97.00 (6.31)	
	Directional control (%)	Myopic	80.60 (3.08)	.096
		Healthy	83.20 (4.95)	
Modified clinical test of sensory interaction in balance	Eyes open, firm surface	Myopic	0.61 (0.39)	.414
		Healthy	1.31 (3.24)	
	Eyes closed, firm surface	Myopic	0.40 (0.20)	.188
		Healthy	0.32 (0.96)	
	Eyes open, foam surface	Myopic	0.73 (0.20)	.383
		Healthy	0.67 (0.15)	
	Eyes closed, foam surface	Myopic	1.04 (0.19)	.261
		Healthy	1.80 (2.58)	

**P* < .05. SD, standard deviation.

Table 3. Knee Proprioception with Biodex Isokinetic Dynamometry

Groups	Degree	Dominant, Mean (SD)	*P*	Non-dominant, Mean (SD)	*P*
Myopic	30	37.94 (6.54)	.400	29.43 (9.10)	.222
Healthy	30	36.23 (4.12)		32.94 (5.95)	
Myopic	60	65.44 (8.44)	.075	56.52 (6.66)	.061
Healthy	60	59.46 (9.26)		61.56 (7.45)	
Myopic	90	89.30 (5.90)	.443	85.59 (6.25)	.533
Healthy	90	91.16 (7.17)		86.88 (4.82)	

SD, standard deviation.

A sense of vision is critical to achieving and maintaining balance. The visual system is the structure that gives the fastest feedback to the central nervous system. The structures of this system constitute approximately 70% of the body's sensory receptors.[19] Thus, the visual inputs perceived through the receptors strongly support the postural stabilization process. Visual acuity affects visual input quality, and refractive errors such as myopia cause a decrease in visual acuity.[20] It is essential to examine both visual acuity and refractive errors to support postural stabilization.[21] Therefore, when evaluating the balance of individuals with visual impairment, the presence of refractive errors should be carefully questioned, and corrections should be made with appropriate orthoses such as glasses or lenses.[22] There are few studies in the literature on this topic. Most of the studies are designed to compare the data of partially or fully blind individuals and healthy people, not refractive errors.

Postural sway correlates with the increased blurring of vision.[23] According to our results, the step widths, sway speed, endpoint-sway, and movement of velocity (MVL) of individuals with myopia were higher than those of the healthy subjects. Alghadir et al[9] evaluated the postural sway with the NeuroCom Balance Master device on a foam surface with visually impaired participants. The sway speed was found to be higher than that for healthy individuals with eyes open.[9] Another study reported that postural release increased in individuals with visual impairment.[2] In the balance assessment performed with the eyes open, it was observed that individuals with healthy vision had better postural stability compared to people with visual problems, because individuals who have healthy eyes constantly receive correct inputs from all 3 main systems to maintain their balance while the eyes are open. Failure in one of these systems increases the load on other systems and causes compensation mechanisms to be activated.[24] However, compensation mechanisms cannot manage the process as well as the main system. For this reason, decreases occur in balance reactions. In addition, standard sensory input greatly reduces with vision loss. Feedback mechanisms are affected by the decrease in sensory input and cause negative changes in body biomechanics. Then, abnormal postural reflex and motor patterns are revealed. This situation causes postural and balance deficits by affecting the strength distribution of the muscles.[9] In addition, there is an opinion that visual cues and visual information from the environment are important sources of feedback for balance performance. Therefore, individuals with visual impairment have more body sway, and this situation is partly explained by the lack of interaction between visual and motor experience.[25]

There was no significant difference between groups in the balance assessment performed with eyes closed. A previous study observed that individuals with congenital visual impairment had better balance scores than individuals with normal vision who were assessed with their eyes closed.[26] Zetterlund et al[27] reported no symptoms of problems in balance, or in the visual and musculoskeletal systems, in individuals with normal vision. However, it has been reported that the symptom levels of young and older adults with visual impairment are equal. It has been emphasized that the most prominent risk factors for the occurrence of this condition are anisometropia and the use of glasses.[27] Interruption of visual input when the eyes are closed causes overactivation of the vestibular and somatosensory systems. In this way, sensory feedback conditions become balanced for visually impaired and healthy individuals.[26]

Proprioception is the ability to perceive the extremity's position in space, thanks to the neural input provided by the joint and the structures around the joint. Among previous studies, we could not find any study for the evaluation of proprioception in refractive errors. We evaluated the sense of proprioception in 3 different angles in myopic individuals. We could not detect a difference in proprioceptive evaluation between myopic individuals and their healthy peers. Zetterlund et al[11] stated that balance and proprioceptive complaints are symptoms resulting from low vision. In addition, they reported that there was a 0.89 negative correlation between improvements in visual functions and balance-proprioception complaints.[11] On the contrary, Giagazoglou et al[25] stated that individuals with visual impairment use the proprioceptive system more due to the decrease in visual input during functional activities, and thus their proprioceptive senses may be more developed.[25] Sensory integration plays an essential role in motor skills and spatial orientation. The somatosensory system provides the integration of information from the upper and lower extremities. In this way, there is a hypothesis that it compensates for visual impairment-related problems.[28] In addition, when congenitally blind individuals were evaluated by functional magnetic resonance imaging, it was observed that the deactivation process in the visual cortex triggered other system activations.[26] In our results, no significant difference was observed in proprioception. We think that the possible reason is that visual input is not interrupted despite the decrease in visual acuity due to myopia.

As far as we know, this is the first study in the literature to compare the balance and proprioception measurements between individuals with myopia and those of their healthy peers. This is the strongest aspect of our study. To evaluate balance and proprioception measurements, computer-assisted devices were used. The objective results obtained from these devices increased the reliability of the data. There were also some limitations in this study. The sample size was limited due to the long duration of objective measurement methods and clinical access difficulties. In addition, measurements of individuals with myopia were performed without orthoses. Since our cases had mild myopia, these measurements should also be made with individuals with higher degrees of myopia.

Conclusion

Our paper showed that the step width and swing speed of the individuals with myopic refractive error was different from those of the healthy peers. Based on these results, we think it is important to consider refractive eye defects in studies where balance may affect the methodological results. It is recommended that individuals who use orthoses such as glasses or contact lenses use these orthoses during balance measurements.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Marmara University Faculty of Health Sciences (Date: January 3, 2019; Code Number: 13).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer Review: Externally peer-reviewed.

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Conflict of Interest: The authors have no conflict of interest to declare.

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