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Research Article

The Comparison of Balance and Coordination Between Congenitally Blind and Sighted Individuals

Doğuştan Kör ve Sağlıklı Bireyler Arasında Denge ve Koordinasyon Karşılaştırması

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ÖZ

Amaç: Görme, statik ve dinamik postürün korunmasında, hareketlerin koordinasyonunda ve dengenin sürdürülmesinde rol oynayan bir sistemdir. Bu çalışmanın amacı doğuştan kör ve sağlıklı bireyler arasında denge ve koordinasyon fonksiyonlarını karşılaştırmak ve dengenin sürdürülmesinde görmenin rolünü belirlemektir. **Gereç ve Yöntem:** Bu tanımlayıcı çalışmaya yaşları 18-40 arasında değişen 19 doğuştan kör ve 18 sağlıklı sedanter birey olmak üzere toplam 37 katılımcı dahil edildi. Her iki grupta Berg Denge Ölçeği (BDÖ), Tinetti Denge Testi (TDT) ve Tinetti Yürüme Testi (TYT) ölçekleri ölçüldü. Sonuçlar: Doğuştan kör ve sağlıklı birey grupları arasında BDÖ, TDT ve TYT ölçeklerinde anlamlı bir fark bulundu ($p<0.05$). Doğuştan kör olan grupta BDÖ, TDT ve TYT skorları daha düşüktü. Tüm katılımcılarda BDÖ ile TDT ($r=0.676$, $p<0.05$) ve BDÖ ile TYT ($r=0.601$, $p<0.05$) arasında pozitif yönde orta düzeyde istatistiksel olarak anlamlı bir ilişki vardı. Doğuştan kör ve sağlıklı gruplarda sırasıyla BDÖ ile TYT ($r=0.632$, $p<0.05$), BDÖ ile TDT ($r=0.642$, $p<0.05$) arasında pozitif yönde orta düzeyde istatistiksel olarak anlamlı bir ilişki vardı. Ancak, doğuştan kör ve sağlıklı gruplarda BDÖ ile TYT arasında anlamlı bir ilişki bulunmadı ($p>0.05$). **Tartışma:** Çalışmanın sonuçları görmenin denge üzerindeki etkisini doğrulamıştır. Doğuştan körlüğü olan kişilerde denge sorunları değerlendirilmeli ve dengeyi geliştirmeye yönelik egzersiz programları yapılmalıdır.

Anahtar Kelimeler: Körlük; Postural Denge; Görme Bozuklukları

ABSTRACT

Purpose: Vision is a system that plays a role in the maintenance of static and dynamic posture and coordination of movements, and sustaining balance. The aim of this study was to compare the balance and coordination functions between congenitally blind and sighted individuals and to determine the role of vision in maintaining balance. **Material and Methods**: In this descriptive study, a total of 37 participants (19 congenitally blind and 18 sighted sedentary individuals) aged between 18 and 40 years were included. Berg Balance Scale (BBS), Tinetti Balance Test (TBT), and Tinetti Gait Test (TGT) scales were measured in both groups. **Results**: A significant difference was found in BBS, TBT, and TGT scales between congenitally blind and sighted individual groups ($p<0.05$). BBS, TBT, and TGT scores were lower in the congenitally blind group. There was a positive moderate statistically significant relationship between BBS and TBT ($r=0.676$, $p<0.05$), BBS and TGT ($r=0.601$, $p<0.05$) in all participants. In the congenitally blind and sighted groups, there was a positive moderate statistically significant relationship between BBS and TBT ($r=0.632$, $p<0.05$), and between BBS and TBT ($r=0.642$, $p<0.05$), respectively. However, there was no significant relationship between BBS and TGT in the congenitally blind and sighted groups ($p>0.05$). **Conclusion:** The results of the study confirmed the effect of vision on balance. Balance problems in people with congenital blindness should be assessed, and exercises to improve balance should be carried out.

Keywords: Blindness; Postural Balance; Vision Disorders

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Vision is a system that plays a role in protecting and maintaining static and dynamic postural control, balance, and neuromuscular coordination, working in conjunction with the somatosensory and vestibular systems (Walicka-Cupryś, Rachwał, Guzik et al., 2022). Visual stimuli are used in the performance of tasks that require motor skills and coordination, and these stimuli are used to determine and control the maintenance of movement (Bednarczuk, Wiszomirska, Rutkowska et al., 2021). Skills such as visual acuity, contrast sensitivity, and ocular alignment contribute to postural oscillation rhythm and static and dynamic balance (Choi, Wong, Cheung et al., 2022). Feedback from the visual system helps maintain control of posture, balance, and gait, reducing the risk of falls (Zetterlund, Lundqvist, Richter, 2019). In addition to the visual system, the vestibular system, which responds to the position of the head in space, and the somatosensory system, which responds to pain, heat, touch, and proprioception, and tension in muscle spindles, all help to maintain postural control and balance (Zarei, Norasteh, Lieberman et al., 2025).

Balance is defined as the ability to maintain body position, move voluntarily, and respond to sensation (Yoward, Doherty, Boyes, 2008). In general, it can be defined as the perception of the place which an individual occupies in space (Geuss, Stefanucci, Benedictis-Kessner et al., 2010). The system that keeps our body in balance is very complex and does not depend on a single organ. Balance is provided by the coordinated functioning of the cerebrum, cerebellum, medulla spinalis, proprioceptors in the joints and muscles, eyes, and vestibular system in the inner ear (Horak, 2006). Balance is provided by the integrity of vestibular proprioceptive, motor, and visual neurophysiological structures. If any one of these is deficient, balance will be adversely affected (Siegel, Marchetti, Tecklin, 1991). The vestibular system plays a role in maintaining the upright position of the body in different environments, using information from many systems such as hearing, vision, and muscular structures, as well as maintaining balance in relation to gravity when walking (Singh, Heet, Guggenheim et al., 2022).

Motor function is also affected by the problems with muscle control and balance that can occur in congenitally blind people as a result of vestibular dysfunction (McDonnell & Hillier, 2015). The vestibular system is a mechanism for perceiving gravity and head acceleration and controlling posture. It contributes to postural stability with functions such as the position of the head in space and the fixation of the eyes during head movement (King & Horak, 2014). The vestibular system is both a sensory and motor pathway. As a sensory pathway, vestibular information is closely related to somatosensory and visual information, allowing the central nervous system to predict the position and movement of the whole body and environment (Cullen, 2012). The vestibular system also contributes to motor control. Descending motor pathways, such as the vestibulospinal tracts, receive vestibular information to control the orientation of the eye, head, and trunk, and to coordinate postural movements (Willoughby, Ponzin et al., 2010). Postural stability depends on the integration of information from the proprioceptive, vestibular, and visual sensory systems. It has been observed that visually disabled individuals have problems with postural stability and balance related to inadequate information from the visual system (Ray, Horvat, Croce et al., 2008).

The aim of this study was to compare the balance, coordination, and gait parameters between congenitally blind and sighted sedentary subjects.

MATERIALS AND METHODS

Study Design

This prospective, single-centre, and descriptive study was conducted at Avrasya University between 25 December 2022 and 25 July 2023. The clinical trial number was NCT06687915. Written informed consent was obtained from participants. In the case of congenitally blind participants, the content of the study was explained to the participants verbally by their parents. The study was completed in accordance with the Declaration of Helsinki.

Participants

Participants, who are congenitally blind and are sighted sedentary subjects, aged between 18 and 40 years, male and female, are included. The congenitally blind participants were recruited through the Trabzon Alti Nokta Blind Association. The sighted sedentary group was made up of volunteers who were invited to participate at Avrasya University University.

Inclusion Criteria

The inclusion criteria were defined as being 18 years of age or older, congenitally blind, having no disability other than visual impairment, open to communication, and able to cooperate. For the sighted group, participants were defined as being 18 years or older, able to read and write Turkish, and not professionally involved in sports. Exclusion criteria were having another acute or chronic disease, musculoskeletal deformities, use of medication affecting cognitive ability, and not having received physical therapy or exercise training before.

Assessments

Socio-Demographic Form

The socio-demographic form was prepared by the researcher and used to determine the effect of the demographic information obtained from the form on the possible outcomes of the study. The height and weight of the participants were measured using a height-weight analyser scale (Medikaltec BYH01). The body mass index (BMI) was then calculated.

Berg Balance Scale

The Berg Balance Test (BBS) is a scale that helps to assess the increased risk of falling in the population at risk of falling due to a chronic disease or disability (Miranda & Tiu, 2025). It is a preferred scale because it is quick and easy to use in different disease types and environments. It is a test that can be used as part of treatment to determine the patient's expected goals in activities of daily living.

BBS has been developed to assess postural control (Berg, Wood-Dauphinée, Williams et al., 1992). It contains fourteen items, and for each item, the patient's performance is observed, and a score between 0 and 4 is given. A score of 0 is given if the patient cannot perform the activity at all, while a score of 4 is given if the patient can perform the activity independently. The maximum score is 56, with 0-20 points indicating impaired balance, 21-40 points indicating acceptable balance, and 41-56 points indicating good balance. The scale takes between 10 and 20 minutes to complete (Blum & Korner-Bitensky, 2008). The Turkish validity and reliability of the scale were developed by Sahin et al. (2008).

Tinetti Balance and Gait Test

The Tinetti Balance (TBT) and Gait Test (TGT) is an inexpensive, simple, and reproducible method of measuring a patient's risk of falling (Scura & Munakomi, 2022). If the patient's total score is low, it leads to the identification of the underlying disability or disease and the implementation of appropriate lifestyle modifications. The fact that it can be used in all patients at risk of falling due to chronic disease or disability is the reason why it was preferred in this study.

TBT and TGT consist of two parts: balance and gait. The balance section consists of 9 items, and the gait section consists of 7 items. Tinetti's total score of <18 shows a high risk of falling, a score between 19-23 is considered to be at moderate risk, and a score of >24 is considered to be at low risk (Scura & Munakomi, 2022). The Turkish validity and reliability of the Tinetti Balance and Gait Test were developed by Ağırcan (2009).

Sample size

Sample size was calculated using G-Power (Version 3.1.9.7, for Windows software). Since the BBS, TBT, and TGT scales were primarily used in this study, the test family was chosen as the 't-test' and the statistical test was chosen as the 'difference between two independent means (two groups)'. Sample size was calculated to be 32 participants with a 5% type 1 and 20% type 2 error limits to provide 80% power, to gain 0.90 of effect size, and a 95% confidence interval. The significance level was accepted if $p<0.05$.

The study included 18 visually impaired and 19 sighted participants to ensure homogeneity. In order to avoid loss of data, five additional participants were included, and a total of thirty-seven participants completed this study.

Statistical Analysis

Data were analysed using the statistical package program IBM SPSS Statistics Standard Concurrent User V 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics were given as number of units (n), percentage (%), mean ± standard deviation (Mean±SD), median (M), minimum (min), and maximum (max) values. The normal distribution of the numerical variables was evaluated by the Shapiro-Wilk normality test. Participants' age, height, weight, and BMI measurements were normally distributed. TBT, TGT, and BBS measurements were not normally distributed. When the differences between two groups were to be evaluated, the Independent Samples t Test was used when the parametric test prerequisites were met, and the Mann-Whitney U test was used when they were not met. The relationships between numerical variables were evaluated with the Spearman correlation coefficient. The absolute magnitudes of the observed correlation coefficient in the previous study [22]. $p<0.05$ was considered statistically significant.

RESULTS

The flow diagram of the study is shown in Figure 1. The physical characteristics of the participants are shown in Table 1. There was no statistical difference regarding the physical characteristics of participants ($p>0.05$).

In Table 2, scores of the BBS, TBT and TGT scales were compared between congenitally blind and sighted individual groups. A significant difference was found in BBS, TBT and TGT scales between congenitally blind and sighted individual groups ($p<0.05$). BBS, TBT, and TGT scores were lower in the congenitally blind group. When the BBS score ranges were evaluated for both groups, acceptable balance was found in the congenitally blind group and good balance in the healthy group. When the Tinetti total score ranges were considered, the balance was medium risk in the congenitally blind group and low risk in the sighted group.

Table 1. The physical characteristics of the participants.

	Groups			
	Blind *n*=19	**Sighted** *n*=18	x^2	**p**
Gender, *n* (*%*)				
Female	12 (63)	9 (50)	0.652	0.419
Male	7 (37)	9 (50)		
			t	**p**
Age, (*years*) Mean±SD	30±7.54	29±4.37	0.418	0.678
Height, (*meter*) Mean±SD	1.68±0.08	1.69±0.10	-0.387	0.701
Weight, (*Kilogram*) Mean±SD	66±14.68	70±16.4	-0.926	0.361
BMI, (*kg/m²*) Mean±SD	23±4.19	24±3.95	-0.915	0.366

t: Independent Samples t test, x^2: Chi-Square test, M: Median, n: number of participants, BMI: Body mass index, Min: Minimum, Max: Maximum, p>0.05.

Table 2. Comparison of Balance Scales Between Congenitally Blind and Sighted Individuals.

	Groups			
	Blind *n*=19	**Sighted** *n*=18	**U**	**p**
BBS				
Mean±SD	39±7.21	55±0.96	-4.857	0.001*
M (Min.-Max.)	52 (29-56)	56 (52-56)		
TBT				
Mean±SD	14±2.34	15±0.24	-3.132	0.002*
M (Min.-Max.)	15 (7-16)	16 (15-16)		
TGT				
Mean±SD	9±2.22	11±0.5	-4.161	0.001*
M (Min.-Max.)	10 (5-12)	12 (11-12)		
Tinetti Total Score				
Mean±SD	23±4.56	26±0.74	-1.101	0.013*
M (Min.-Max.)	22 (12-28)	25 (26-28)		

*U: Mann-Whitney U Test (z), BBS: Berg Balance Scale, TBT: Tinetti Balance Test, TGT: Tinetti Gait Test, SD: Standard Deviation, M: Median, Min: Minimum, Max: Maximum, *p<0.05.*

In Table 3, the correlation analysis of the BBS, TBT, and TGT scales was shown in all participants, including congenitally blind and sighted individuals. There was a positive moderate statistically significant relationship between BBS and TBT (r=0.676, p<0.05), BBS and TGT (r=0.601, p<0.05) in all participants. In the congenitally blind and sighted groups, there was a positive moderate statistically significant relationship between BBS and TBT (r=0.632, p<0.05), and between BBS and TBT (r=0.642, p<0.05), respectively. However, there was no significant relationship between BBS and TGT in the congenitally blind and sighted groups (p>0.05).

Table 3. Relationships Between BBS, TBT, and TGT Scores According to the All Participants and Disability Status.

		r	p
All participants	BBS-TBT	0.676	0.001*
	BBS -TGT	0.601	0.001*
Blind	BBS-TBT	0.632	0.004*
	BBS -TGT	0.343	0.150
Sighted	BBS-TBT	0.642	0.004*
	BBS -TGT	-0.282	0.258

*BBS: Berg Balance Test, TBT: Tinetti Balance Test, TGT: Tinetti Gait Test, r: Spearman correlation coefficient, *p<0.05, p>0.05.*

DISCUSSION

The study conducted to compare balance, coordination and gait parameters between congenitally visually impaired individuals and sighted sedentary individuals showed a significant decrease in balance control in congenitally visually impaired individuals. This finding emphasises the negative effect of congenital visual impairment on balance.

Aartolahti et al. (2013) investigated the relationship between balance and mobility in participants aged sixty-five years and older with visual impairment and good functional vision. The study found that participants with visual impairment performed worse on balance and mobility scores. Zipori et al. (2018) compared the balance levels in groups of children with amblyopia, children without amblyopia but with strabismus and healthy children and found that children with amblyopia and strabismus had lower balance performance compared to healthy children (Zipori, Colpa and Wong, 2018). Urbaniak-Olejnik et al. (2022) conducted a study with 30 participants with congenital visual impairment on a stable and unstable surface and found that while there was no difference between balance scores on a stable surface, balance scores of visually impaired individuals on an unstable surface were lower than those of healthy individuals (Urbaniak-Olejnik et al., 2022). Similarly, lower balance scores were found in individuals with congenital visual impairment compared to sighted individuals in this study.

Haibach et al. (2011) compared balance scores and balance self-efficacy in congenitally blind, visually impaired, and healthy adolescents and found that the degree of visual impairment was an important factor in balance scores but not sufficient for balance self-efficacy. This demonstrates the importance of using more than one balance scale to define different components of balance. Zyłka et al (2013) performed a paediatric balance scale and functional balance measurement in girls with visual impairment and found that balance difficulties occurred in single-leg standing, tandem standing and forward reaching. A positive unidirectional correlation was found between the paediatric balance scale and functional balance measurement (Zyłka, Lach and Rutkowska, 2013). Similarly, our study found a positive unidirectional correlation between the Berg balance test and the Tinetti balance test in congenitally visually impaired individuals.

In order to investigate the permanent effect of visual impairment on balance, Schwesig et al. (2010) conducted a postural analysis with eyes open and closed on hard or foam surfaces that reduce somatosensory input in congenitally visually impaired, acquired visual impairment and healthy individuals and found that the somatosensory system establishes a compensatory mechanism in maintaining posture in individuals with congenital and acquired visual impairment. Alghadir et al. (2019) investigated the change in centre of gravity velocity, an important parameter for postural control in individuals with visual impairment, and compared the change in centre of gravity velocity of sighted and visually impaired individuals on an unstable floor. As a result of the study, a difference in centre of gravity velocity was found between sighted and visually impaired participants

(Alghadir, Alotaibi, et al., 2019). Willis et al. (2013) conducted a balance test to better understand the causes of falls in individuals with visual impairment, uncorrected refractive error and normal vision. In the balance test, the time to balance failure was measured while the participants were standing on a hard or foam surface with their eyes open or closed, and as a result, worse balance scores were obtained in individuals with visual impairment and uncorrected refractive error (Willis et al., 2013). This indicates that balance is worse in individuals with vestibular visual impairment and uncorrected refractive error, and reduced visual input may weaken the vestibulo-ocular reflex. Multidimensional evaluation of balance may emphasise different intervention methods in the rehabilitation phase.

Several studies have shown that the balance of visually impaired individuals is worse than that of sighted individuals. This situation is not only limited to balance scores but also varies in several dimensions. As a result of visual deficits, individuals become more dependent on the vestibular and somatosensory systems as they lack visual information to maintain balance (Haibach, Lieberman and Pritchett, 2011). Particularly in static and dynamic postural control tasks, this leads to increased postural sway and difficulties in maintaining balance (Rutkowska et al., 2016). In addition, performance in tasks such as stepping back, changing direction and turning is decreased, related to delayed motor planning and balance-correcting responses in visually impaired (Atasavun Uysal et al., 2010). Lack of spatial awareness complicates the perception of environmental cues, leading to disorientation during walking (Omidi et al., 2024). In walking patterns, step length is shortened, walking speed is decreased, and a more cautious style is adopted (Haibach, Lieberman and Pritchett, 2011). In addition to all these factors, psychosocial factors such as fear of falling and low physical activity level are also important dimensions that negatively affect balance (Aytar et al., 2009). These differences result in significant score differences in balance tests such as the Tinetti and Berg, and indicate that visually impaired individuals have a higher risk of falling.

The demonstration of balance and gait impairment in individuals with congenital visual impairment has also revealed the need for the application of various exercise approaches (Salar et al., 2022). Gleeson et al. (2015) investigated the effect of Alexander exercise training on physical parameters such as postural sway, walking speed, stride length and standing on a chair in visually impaired individuals aged 50 years and older and found a significant decrease in the fall rate of participants after exercise training (Gleeson et al., 2015). Chen et al. (2012) investigated the effect of Tai Chi exercises on balance in visually impaired individuals aged 70 years and older, and found significant improvements in knee proprioception and balance after exercise intervention (Chen et al., 2012). Rogge et al. (2019) examined the effect of balance training on balance performance and cortical and subcortical areas in the brain in visually impaired adults and found that balance training caused an increase in static and dynamic balance performance by causing plasticity in cortical and subcortical areas (Rogge, Hötting and Nagel, 2019). Özkan et al. (2021) showed the effect of postural stability training on occupational performance and postural stabilisation in visually impaired participants. As a result of the study, it was found that postural stability exercises were effective in increasing postural stability and occupational performance.

Monti Bragadin et al. (2015) found a strong correlation between the Tinetti and Berg balance measures in peripheral neuropathy patients with balance problems. Miodonska et al. (2018) found a significant correlation in the parameters of step angle change, step swing and mean stance phase duration in their gait analysis in geriatric patients classified into low and medium fall risk classes according to Tinetti and Berg balance scale scores. Similarly, a positive correlation was found between the BBS and TBT scores of both sighted and blind subjects in our study. This result showed that both scales gave parallel results in measuring balance in participants at low or moderate risk of falling.

Our study has several limitations. The first limitation is that a physical measurement and assessment method was not used with the participants, along with the balance scales. The second limitation is that the balance measurements were made with scales, and a digital balance measuring device was not used. As the digital balance measurements are interpreted by recording numerical parameters such as postural disorders affecting balance and pressure changes when the foot contacts the ground, it may provide more accurate results than scales. The strength of our study is that we used two different scales in balance measurement and investigated the relationship between them.

CONCLUSION

In conclusion, congenital blindness was associated with poorer balance and functionality on both static and dynamic balance scales in community-dwelling adults. The assessment of balance from different perspectives using different balance scales and the determination of the relationship between them shows that balance is a concept that should be assessed in a multidimensional way. A multidimensional assessment of balance impairment due to congenital visual impairment may indicate the need to re-evaluate the effect of different and innovative exercise approaches on these outcomes.

Ethical Approval

The protocol of the study was approved by the Ethics Committee of Istanbul Okan University Science, Social and Non-Interventional Health Sciences (Date: 26/10/2022, No: 159).

Authors' Contribution

Please write here as it is written on the cover page.

Conflict of Interest

The authors declare no conflict of interest.

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