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Original Article

Physiology Section

Comparison of Gait Pattern among Blind and Blind Folded Sighted Subjects: A Cross-sectional Study

SWETA KUMARI[1], NAVEEN BANKEY[2], SHOMI ANAND[3]

ABSTRACT

Introduction: Gait is the normal way of walking pattern. The visual system of sighted subjects furnishes information concerning the environment from distant and plays important role in maintaining the stability and planning of the route during locomotion. During movement of the sighted subject, the visual perception of the surroundings enables the orientation towards the goal. Movement and position of limbs is also important in order to adjust foot clearance or foot placement to regulate the walking pace.

Aim: To compare the gait pattern among blind and blind folded sighted subjects as well as among healthy and underweight blind and blind folded sighted subjects.

Materials and Methods: The cross-sectional study was conducted in Department of Physiology, RKDF Medical College Hospital and Research Centre, Bhopal, Madhya Pradesh, India, from October 2019 to April 2021. A total of 181 sighted and 150 blind subjects aged between 10-17 years were taken in the study. Foot print method was used to record spatial components. The temporal components were measured with stop watch. Rivermead Visual Gait Analysis (RVGA) was used to analyse kinematic characteristics. The estimation of healthy and underweight subjects were done by calculation of Body Mass Index (BMI). Quantitative data was expressed as mean±standard deviation. Statistical Package for the Social Sciences (SPSS) version 20.0 was used for statistical analysis.

Results: The mean value of gait in blind folded sighted and blind subjects was found to be 3.28±0.48 and 2.01±0.79 km/hr respectively and was found statically significant having (p-value=0.001). The results of mean value of gait on the basis Body Mass Index (BMI), the healthy blind folded sighted and healthy blind subjects showed 3.29±0.46 and 1.99±0.75 respectively (p-value=0.001). Similarly, the gait pattern in underweight blind folded sighted and underweight bind subjects was observed to be 3.26±0.61 and 1.98±0.77 km/hr respectively (p-value=0.001).

Conclusion: The gait pattern was found to be significantly better among the blind folded sighted subjects in comparison to the blind subjects.

Keywords: Foot, Movement, Perception, Stability, Visual

INTRODUCTION

Gait is a manner of walking pattern of the individuals. It involves balance and muscles coordination so that the body is propelled forward in a flow. In general, the characteristic of gait pattern is instituted during the course of motor development for specific situations. The gait patterns are well assembled and established as motor patterns in brain mostly at the seventh years of the childhood age [1]. There may be inadequate gait process in case of any damage at cognitive or organic level of an individual. Locomotion is to walk gracefully, comfortably and safely [2]. The system of vision helps to receive knowledge about the environment from a distance and plays an essential role during mobility in the preservation of balance and for planning of route. Visual appreciation of the environments during locomotion allows orientation towards a goal, adjusting moving direction, avoiding strikes with objects, keeping away obstacles and accommodating different surfaces.Visual perception of self-motion, limb movement and limb motion is also essential in order to adjust either foot clearance or foot placement and to regulate the pace movement [3,4,5].

Most often, it has been observed that the congenital blind individuals have shorter and wider stride length. They show flexed knees even at stance, reduced speed and heel strike causing dragging. They do not exhibit swinging of reciprocal arms and increased in out toeing than the normal sighted person. They also show higher error in foot placement and generally get deviated from the straight path [6].

A few studies exist reporting on the movement of the body during locomotion among visually challenged subjects. Most of the studies pointed out the effect of low sight on mobility of older people [7]. The execution of mobility is frequently distinguished by percentage of preferred walking speed acquired in a disordered environment. In the study of Hallemans A et al., it had been observed that the percentage of preferred walking speed reduced in case of subjects with low vision and in congenitally visual challenged subjects [8]. Turano KA et al., observed that the glaucoma in subjects is associated with decreased walking performance. They stated that mean walking pace of the glaucoma subjects was 10% slower than the mean walking pace of the normal sighted subject [9]. Nakamura T observed that, the visually impaired individuals, either congenital or late blind showed decreased speed, small stride length and increased stance duration [6].

Some observations are available on kinematics movement in case of reduced vision. It was also observed that cataract enhanced the toe clearance and substantial variability of limb elevation during hurdle avoidance task [4]. Nakamura T also compared step time parameters of gait in normal sighted, late blind and congenital blind individuals. Where, the sightless persons had always shown decreased walking pace, reduced stride length and increased time of instance. Therefore, these findings support a better stability of the posture in case of vision loss [6].

Abualait TS and Ahsan M, mentioned that walking patterns of the individuals also fluctuate by age, BMI, surface, course of time, and it changes from stride to stride [10]. Since, walking is an important factor of gait, it depends on inter-relationship between central nervous system and musculoskeletal system. The balance of an individual can also be disturbed by weight alterations with respect to physical status of individual. An increased or decreased body mass have been observed for variations in gait pattern of individuals in the same age group [11]. There is dearth of study on effect of BMI on

gait pattern among blind folded sighted subjects and blind subjects. Thus, aim of the present study was to investigate and compare the gait pattern on the basis of BMI among the blind folded sighted and blind subjects aged between 10-17 years.

MATERIALS AND METHODS

The cross-sectional study was conducted in Department of Physiology, RKDF Medical College Hospital and Research Centre, Bhopal, Madhya Pradesh, India, from October 2019 to April 2021. The study included 181 sighted and 150 blind subjects of either sex and age group between 10-17 years. The written informed consent was received from all the participants (331) and ethical clearance (Ref outward No.540A) was obtained from Institutional Ethical Committee prior to conduct the study.

Inclusion criteria: Sighted and blind subjects aged between 10-17 years of both sexes were included in the present study.

Exclusion criteria: Subjects with any type of neurological illness that affect our sensory and motor function, brain damage, traumatic brain injury, autoimmune disorder, substance abuse, attention deficit disorder, learning disability were excluded from the present study.

The estimation of healthy and underweight children was done by calculation of BMI i.e., BMI=weight/height (kg/m^2). The BMI in childhood changes substantially with age [12]. The cut-off values of BMI of underweight subjects aged 10 years, 11 years,12 years, 13 years, 14 years, 15 years, 16 years and 17 years are <13.4, <14, <14.4, <14.8, <15.4, <15.9, <16.4 and <16.8 respectively. Whereas, the BMI (kg/m^2) of normal healthy subjects aged 10 years, 11 years, 12 years, 13 years, 14 years, 15 years, 16 years and 17 years are 13.7-18.5, 14.1-19-2, 14.1-19.2, 14.5-19.9, 14.9-20.8, 15.5-21.8, 16.0-22.7, 16.5-23.5 and 16.9-24.3 respectively [13].

Procedure

The scale used for the present study was Rivermead Visual Gait Analysis scoring (RVGA) [14]. The 10 meter walkway distance was marked on corridors having smooth surface, hard without any hurdle and pleasant surroundings were provided to both groups. The participants were described about the present study and instructed to walk with congenial walking pace. Further no commands were given for style of walking and posture correction aspects. Footprint method was used to note spatial components. The temporal parts were measured with a stopwatch and manual measurement of steps. White cardboard paper with dimension 2 feet wide and 6 feet long was attached in the walkway with adhesive tape and the subjects were instructed to walk on the given walkway after their feet were inked as shown in [Table/Fig-1,2]. The subjects were advised to walk as straight as possible freely till they were told to stop. The assessments of stride length, step length, frequency of steps, time taken for participants to finish 10 m distance were written down. Walking speed was calculated as distance walked in second i.e., 10 meters/total time taken in seconds. The cadence was calculated with the use of steps frequency for the duration of 10 m walkway by formula cadence [15] i.e.,

Number of steps per minute=No. of steps taken during 10 m walk× 60 sec/time taken to complete 10 m walkway in sec.

The variables which were used to determine the gait in present study is in accordance with the study done by Aruna R et al., [16].

[Table/Fig-1]: Step length of gait.
[Table/Fig-2]: Stride length of gait. (Images from left to right)

STATISTICAL ANALYSIS

Quantitative data was expressed as mean±standard deviation. Statistical Package for the Social Sciences (SPSS) version 20.0 was used for statistical analysis with the help of unpaired t-test, p-value <0.05 was considered as statistically significant.

RESULTS

In the present study, the mean age of sighted and blind subjects was observed to be 13.87±2.10 years and 13.92±2.06 years respectively (p-value=0.8193). Demographic details are presented in [Table/Fig-3].

Age group	Sighted (Blind folded)		Blind		Total
	Male	Female	Male	Female	
10-17 years	147	34	138	12	331

[Table/Fig-3]: Total number of male and female blind folded sighted and blind subjects participated in the study.

The mean value of the step length of gait in blind folded sighted and blind was observed to be 0.62±0.04 m and 0.48±0.09 m respectively (p-value=0.001). The mean value of RVGA score of blind folded sighted and blind was 6.5±2.9 and 14.5±4.82 respectively. All these parameters were statistically significant (p-value=0.001) [Table/Fig-4].

Variable	Sighted (blind fold) (Mean±SD)	Blind (Mean±SD)	p-value (Unpaired t-test)
Gait			
Step length (m)	0.62±0.04	0.48±0.09	0.001*
Stride length (m)	1.24±0.08	0.96±0.18	0.001*
Stride rate (Stride/min)	44.06±5.29	33.69±6.64	0.001*
Standing time(sec)	1.38±0.16	1.83±0.32	0.001*
Walking velocity (km/hr)	3.28±0.48	2.01±0.79	0.001*
RVGA score	6.5±2.9	14.5±4.82	0.001*

[Table/Fig-4]: Comparison of the mean gait in blind folded sighted and blind subjects. *p-value <0.05 was considered as statistically significant

The results of mean value of gait on the basis BMI, the healthy blind folded sighted and healthy blind subjects showed 3.29±0.46 kg/m^2 and 1.99±0.75 kg/m^2 respectively (p-value=0.001). Similarly, the gait pattern in underweight blind folded sighted and underweight blind subjects was observed to be 3.26±0.61 and 1.98±0.77 respectively (p-value=0.001) [Table/Fig-5].

Variables	Blind folded sighted (Mean±SD)	Blind (Mean±SD)	p-value (Unpaired t-test)
Step length (meters)			
Healthy	0.62±0.43	0.48±0.09	0.001*
Underweight	0.60±0.038	0.47±0.078	0.001*
p-value of step length between healthy and underweight	0.0674	0.4412	-
Stride length (meters)			
Healthy	1.25±0.078	0.96± 0.179	0.001*
Underweight	1.21±0.076	0.94±0.15	0.001*
p-value of stride length between healthy and underweight	0.0626	0.7355	-

Step rate (per min)			
Healthy	44.96±5.11	33.76±6.60	0.001*
Underweight	44.64±6.42	33.19±7.22	0.001*
p-value of step rate between healthy and underweight	0.5533	0.7847	-
Stand time (sec)			
Healthy	1.32±0.15	1.87±0.41	0.001*
Underweight	1.37±0.19	1.92±0.52	0.001*
p-value of stand time between healthy and underweight	0.7295	0.9117	-
Walking velocity (km/hr)			
Healthy	3.29±0.46	1.99± 0.75	0.001*
Underweight	3.26±0.61	1.98±0.77	0.001*
p-value of walking velocity between healthy and underweight	0.8119	0.9995	-
RVGA score			
Healthy	5.2±1.9	13.4±4.3	0.001*
Underweight	5.9±2.1	14.9±4.9	0.001*
p-value of RVGA score between healthy and underweight	0.4139	0.4197	-

[Table/Fig-5]: Comparison of mean gait of healthy and underweight blind folded sighted and blind subjects.
*p-value <0.05 was considered as statistically significant

DISCUSSION

The present study observations showed that the lack of vision among the blind subjects affected the gait dynamic stability. Hallemans A et al., also observed that the visual deprivation in blind subjects affected spatio-temporal gait parameters [17]. In the present study, it was observed that step length and stride length varied significantly in blind subjects in comparison with blind folded sighted subjects. The decreased stride length in blind subjects, point out the tendency to withstand longer amplitude excursion of centre of gravity from the mid plane of the body. Thus, the reduced stride length and step length helps the blind subjects in maintaining the balance for safety concern [16]. It was also observed that, stride frequency and walking velocity was decreased in blind subjects in comparison to blind folded sighted subjects. These findings are due to the properties of gait not allowing the center of gravity to fall outside the base support in the case of blind subjects. The low pace in terms of steps carried out per minute and the distance travelled in given time represents that the each step is taken carefully with great protection. The conclusion of the present comparative study is supported by the study from Nakamura T [6].

In 1986, Rosen S and Dodson B, mentioned that persons with congenital vision impairment had shown shorter stride length, step length and slow walking velocity. Many researchers have also mentioned, that the stride length and step length of the blind subjects were differed significantly from the normal sighted individuals [18]. The present study had also shown that the blind subjects had shorter stride length mean 0.96±0.18, step length mean 0.48±0.09, stride rate mean 33.69±6.64, standing time 1.83±0.32 and reduced walking velocity mean 2.01±0.79 than the blind folded children having stride length mean 1.24±0.08, step length mean 0.62±0.04, stride rate mean 44.06±5.29, standing time 1.38±0.16 and walking velocity mean 3.28±0.48. The findings in the present study were very much similar to the study done by Aruna R et al., they too had shown the stride length (mean=91.90), step length (mean=45.59), walking velocity (mean=0.6340) and RVGA score (mean=14.00) among blind children. Whereas the stride length (mean=114.7), step length (mean=59.4), walking velocity (mean=0.8245) and RVGA score (mean=6.05) were observed among blind folded normal children [16]. In accordance with the present study, Iosa M et al., have also observed a decreased in preferred walking velocity in blind subjects in comparison to blind folded sighted subjects [19]. This is due to a conventional strategy among blind that the longer time duration in haptic foot exploration reduces the fear of falling.

Shimizu J et al., observed one of the largest statistically insignificant discrepancies in stride rate between the blind and sighted individual, while in the present study the mean stride rate in blind and blind folded sighted subjects was found to be statistically significant (p-value=0.001). Even though the blind subjects was ensured that there was no any object present in their path, they were still very cautious in safety concern [20].

The fact that the significant difference was observed in mean standing time among blind and blind folded sighted subjects indicates that blind subjects show a longer stance parameter of their gait cycle. This contradicts the findings of Hallemans A et al., [8] who observed blind individuals showed a similar stance phase duration.

Lack of visual information in blind subjects affects the gait pattern. Normally, a more careful walking strategy is observed in blind subjects. Our data on decreased gait patterns in blind subjects was due to lack of vision. A similar observation was found by Turano KA et al., who reported the decreases in preferred walking speed among blind individuals due to careful walking strategy followed by blind individuals to prevent from fear of falling [21].

In the present study, authors observed the significantly huge difference in gait patterns in healthy blind folded sighted and underweight blind. Healthy blind folded sighted subjects performed very well in assessment of gait parameters than underweight blind. Since, normal body mass is essential to maintain the postural balance and better gait pattern [11].

The observations in the present study, elicits that vision, as well as body mass of the subjects cumulatively influence the gait pattern in blind subjects. These factors are considered to be important for normal walking patterns irrespective to the hunting of the specific characteristics. Further, these factors should be implemented for adaptation of position of many joints for gait characteristics.

Limitation(s)

The chief limitations of the present study was that there was a need of investigations of more controlled parameters to find out the role of vision as well as body mass index of the participants for better gait analysis. Furthermore, authors have not taken the parameters that are responsible for lateral body swing during blind walk.

CONCLUSION(S)

The present study concluded that the gait pattern was found to be significantly better among the normal sighted subjects than the blind subjects. The typical walking pattern adapted by blind subject to maintain the body stability and prevention from the fear of falling by reducing the step length, stride length, stride rate and walking velocity.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Physiology, RKDF Medical College Hospital and Research Centre, Bhopal, Madhya Pradesh, India.
2. Associate Professor, Department of Physiology, RKDF Medical College Hospital and Research Centre, Bhopal, Madhya Pradesh, India.
3. Associate Professor, Department of Physiology, Government Medical College and Associated Hospital, Rajouri, Jammu and Kashmir, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Sweta Kumari,
Assistant Professor, Department of Physiology, RKDF Medical College Campus,
Jatkhedi, Bhopal, Madhya Pradesh, India.
E-mail: sweta4u123@gmail.com

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