International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effectiveness of Visual Cues and Auditory Cues on Gait Parameters in Individuals with Parkinson's Disease: An Experimental Study

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ABSTRACT

BACKGROUND: Parkinson's Disease (PD) is a progressive disorder of the Central Nervous System. Gait impairments are a common and early feature of PD, and are major cause of functional dependence, falls and death. Approximately 50% of Parkinson's patients have freezing of gait (FOG). Alternative gait rehabilitation technique, such external sensory cueing, which incorporates visual, auditory, and tactile stimulations, have received a lot of attention lately.

AIM OF STUDY: To study the effectiveness of visual cues & auditory cues on gait parameters in individuals with Parkinson's disease.

METHODOLOGY: 30 subjects were selected for study. Subjects were randomly allocated into two groups. Group 1: Auditory cue Group 2: Visual cue, for 1 time/day, 5 days/week, 4 weeks and 20-30 minutes gait training. Both groups receive Conventional Physiotherapy for 20-30 minutes of session. Dynamic Foot Prints, Velocity, Cadence and Tinetti Performance-Oriented Mobility Assessment Test (POMA-G) were taken as an outcome measures and checked before intervention and after the end of 4 weeks.

RESULT: Result shows there is statistically significant difference in within group analysis in step length, stride length, velocity & POMA-G but no difference was found in cadence in both groups (p-value < 0.05). Between group analysis shows statistically significant improvement in POMA-G (p-value < 0.05), but not in step length, stride length, cadence and velocity (p-value > 0.05).

CONCLUSION: As results shows improvement in auditory cue and visual cue groups but there is no significant difference in between group analysis on gait parameters which are step length, stride length, cadence, velocity and POMA-G. It suggests that both interventions are beneficial and can be used in clinical practice easily for the patients who have difficulty in walking with minimum cost of therapists and patients as well.

KEYWORDS: Parkinson's Disease, Gait Disorders, Gait Impairments, Gait Training, Gait Rehabilitation, Auditory cue, Visual cue.

INTRODUCTION

The Progressive Neurodegenerative Disease of the Central Nervous System is called Parkinson's Disease (PD).(1) Typically identified pathologically by Lewy bodies and neuronal loss in the substantia nigra, as well as clinically by a motor phenotype.(2) Affecting 2 in every 100 peoples over 60 years of age and as of

2022 in India. More than 10 million peoples worldwide are living with PD. The number of instances of PD is predicted to rise, reaching 13 million by 2040. Men are more commonly affected by PD than women, while the exact cause is unknown.[3] The World Health Organization's Neurological Diseases Programmed predicts that by 2040, PD will rank second in terms of causes of mortality.[1] The symptoms of PD include bradykinesia, rigidity, tremor, movement, postural instability, and difficulty walking.[2] Gait impairments are a common and early feature of PD, and are major cause of functional dependence, falls and death. Gait impairments in PD can be continuous or intermittent, with deterioration of gait with disease progression. Continuous impairments of gait in PD includes reduced step length, speed, increased double-support time and arrhythmicity, intermittent gait deficits include FOG, which involves failure to initiate or maintain walking.[4] It has been described as a feeling of the feet "glued to the floor".[6] FOG usually occurs during take-off and return but also manifests itself in response to personal constraints, such as passing through narrow streets, doorways, and between two jobs.[4] Falls, and fear of falling (FOF), are common and serious problems in people with PD, which restricts mobility, social participation, and quality of life.[5] Many therapies, including Bobath, Neurodevelopmental Therapy (NDT), and Proprioceptive Neuromuscular Facilitation (PNF), are used to treat motor, gross motor, and balance problems. However, the results of conventional treatments are uncertain and the principles behind them have become controversial. Recently clinical studies have shown an urgent need for alternative treatments that focus on motor control and motor learning rather than post hoc responses like usual treatments. Physical Therapy techniques show that different strategies may help improve walking in some stages of PD. External guidance during recovery is often used for PD patients, who have internal barriers but can use external opportunities to enhance competition.[4,7] Clinical research into the individual effectiveness of cueing strategies on gait parameters and performance for PD patients has been limited. Cueing strategies are not commonly used in clinical practice for the rehabilitative treatment of PD as a gait training. Therefore, the purpose of the present study is to examine the effectiveness of Visual cues and Auditory cues on gait parameters in individuals with Parkinson's disease. Results from this study may help in further Rehabilitation of Parkinson's Disease on gait parameters with minimum cost for the therapists and the patients.

METHODOLOGY

An Experimental Study was conducted for a duration of one year from various Physiotherapy Out Patient Departments, Neurology Clinics and Community after obtaining ethical approval from the Institutional Committee. A written consent form was taken from the subjects. A total sample size of 30 subjects, with 15 subjects in each of the two groups, which was calculated by using power analysis. Considering Level of Significance 0.05 (α) and Power of study 90% (β). Inclusion Criteria: 1) Diagnosis of Parkinson's Disease approved by a Neurologist, 2) Subjects willing to participate, 3) Both males and females were included, 4) Age: 50 to 80 years, 5) Presence of gait deviations due to Parkinson's Disease, 6) Ability to stand independently, 7) 10-meter walk without support of assistive device, 8) Being at stage 4 or below according to the Modified Hoehn and Yahr Scale (MHYS). Exclusion Criteria: 1) Having a hearing and visual deficit (subjects who were using hearing aid and bespectacled are not excluded), 2) MMSE score < 24, 3) Subjects with Cardiopulmonary Diseases, 4) Significant orthopedic or chronic pain conditions affecting gait performance, 5) Any other Neurological Diseases in addition to Parkinson's Diseases. Withdrawal Criteria: 1) If patient wants to withdraw at any time duration of this study, 2) Any medical emergency which required Medical Professionals.

OUTCOME MEASURES

1) DYNAMIC FOOT PRINTS:

For the Dynamic Foot Prints, a 10-meter walkway was used. Dynamic Prints use a substance applied directly to the foot. The subject walked along a surface that was compatible with that substance. Impressions were obtained using ink to generate the footprints. Once adequate footprints were obtained, three successive footprints were identified. It's used to measure the spatial gait parameters by measuring the distance from the midpoint of the heel to the next midpoint of the heel of the same foot for Step length. For step length, distance between heel strike on one foot to heel strike on the contralateral foot, at next ground contact. This technique measures stride length as the distance from the posterior heel bisection of one print to the posterior heel bisection of the following print on the ipsilateral side. It is measured along the ipsilateral line of progression.[8]

2) VELOCITY: SPEED = DISTANCE (METER) / TIME(SECONDS)

Mark off 10 meters on the floor in your clinic with tape, time in seconds how long it takes your patient to walk this far, having them start a few feet before the line and keep going a few feet after the line. Divide the number of seconds by 60 sec/min, to give you minutes. Then divide 10 meters by the number of minutes to give you meters/minute. 60/_____ time (sec) x _____ distance (10 meters) = _____Velocity (meter/min) Reliability: Test-retest Reliability 0.98 [9]

Figure 1 Dynamic Foot Prints

3) CADENCE: NUMBERS OF STEPS/MIN

Have patient walk 30 seconds and count each step, then multiply times 2. You can also just do this for 60 seconds. Cadence can also be assessed in a 10-meter walk – time in seconds and count the number of steps, then calculate: 60/time (sec) x # of steps = Cadence. 60/_____time (sec) x _____ steps = _____ Cadence (steps/min) [9]

4) TINETTI PERFORMANCE-ORIENTED MOBILITY ASSESSMENT TEST(POMA-G):

The Tinetti-test, also called Performance-Oriented Mobility Assessment (POMA), assesses a person's perception of balance and stability during activities of daily living and their fear of falling. Tinetti test had a gait score of 12 and balance score of 16, hence total 28 scores. The lower the score, the higher the risk of falling. Inter-rater Reliability 0.75 ~ 0.90. Test-retest Reliability 0.88 ~ 0.97. Concurrent Validity- 0.64 ~ 0.70 [10]

PROCEDURE

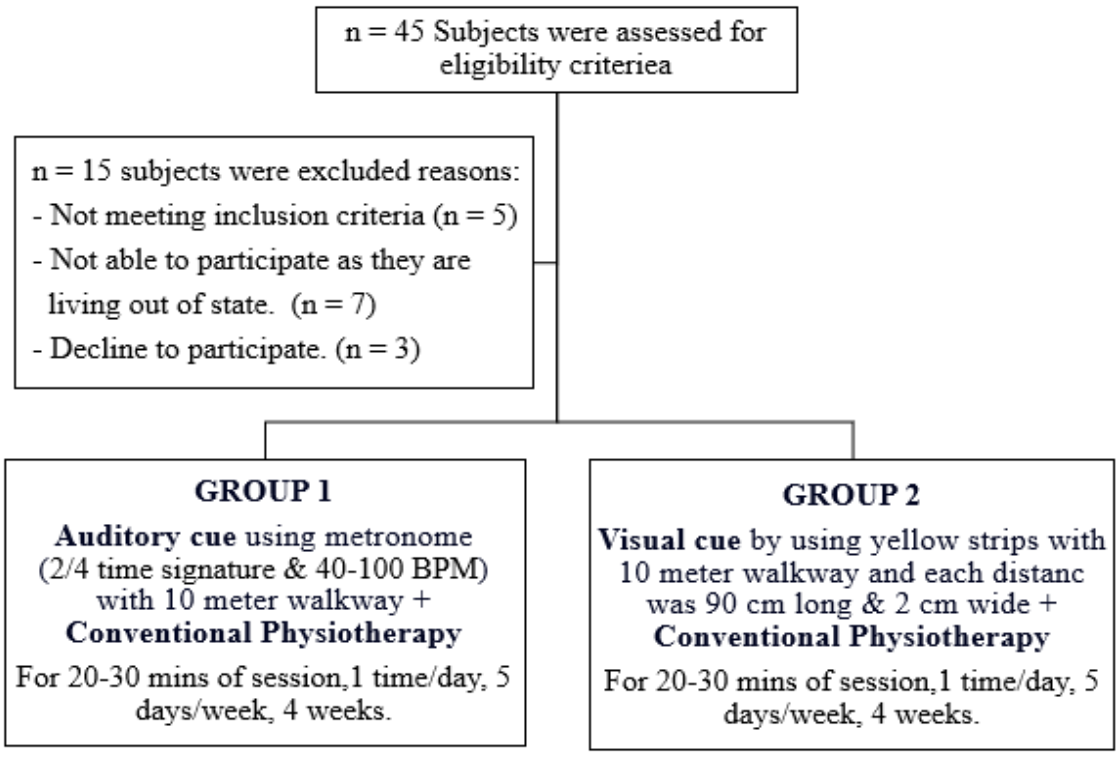
Ethical clearance was obtained from the institutional ethical committee prior to the study. Subjects were verbally explained the purpose of the study, and written consent forms were obtained from the subjects. The data was collected from various Physiotherapy Out Patient Departments (OPD), Neurology Clinics and Community, for a period of 4 months (January 2023 to June 2023). Patients were initially screened based on the inclusion and exclusion criteria. All baseline data were collected for all participants. Initially, 45 subjects were screened for the study, out of which 15 were excluded. Allocation to the groups was done by chit picking. Each participant randomly picked up one chit from an opaque bag, within which contained chits of the same shape, size, and texture with two different colors of paper. Participants had taken one chit from the bag to check the allocation. The whole process was witnessed by their caregivers. No change was made after the allocation. Participants were unaware of the allocation. The study is single-blinded. Group: 1 Auditory cue + Conventional Physiotherapy and Group: 2 Visual cue group + Conventional Physiotherapy. Subject were requested to wear shoes.

GROUP-1 Auditory Cue Group: Rhythmic Auditory Stimulation (RAS) was given using a 'Soundbrenner Metronome' Android-supported application. The rhythmic stimulation using the metronome was composed of a single-tone series in a 2/4-time signature. The initial pace of the participant was measured by playing the RAS, ranging from 40 to 100 BPM (Beats Per Minutes), to set the initial tempo. The identified pace of RAS was chosen to match each individual's original and increased cadence. Subjects were provided with metronome-based auditory rhythms, whose BPM depended on the patient's cadence at baseline. Usually, the BPM was equal to the patient's own cadence or slightly increased or decreased (e.g., +/- 5%, +/- 10%), depending on the characteristics of the subjects. Volume of RAS was provided at 60 decidbel (dB). Step 1: Subjects were helped to adapt to the rhythm by listening to the metronome for 2 minutes before walking with RAS. During this phase, subjects 'swayed their shoulders from side to side' or 'tapped on the floor with their soles' while listening to the beats. Step 2: Next 10 minutes, the patient underwent gait training with RAS, followed by a 10-meter walkway. Step 3: Subsequently, the participants walked without any rhythm for 1 minute, followed by a rest period of 2 minutes. This procedure was repeated twice. Step 4: Data were collected from the time the subject crossed the start of the course to the time they crossed the finish of the course. The time required to complete the 10-meter course was recorded using a digital stopwatch. The number of steps required to complete each trial was counted and used to calculate the average cadence (steps/min). These steps were performed for a duration of 20-30 minutes per session, once a day, five days a week, for four weeks.[11,12]

GROUP-2 Visual Cue Group: The visual cue consisted of yellow strips, 2 cm wide and 90 cm long parallel lines were drawn on a 10-meter walkway. The decision to apply a normal step length was based on recent updates demonstrating that most participants showed vastly improved gait when the visual cue was set for a normal step length. Step 1: All subjects were instructed to walk at a step length as indicated by the yellow strips. For 10 minutes, the subjects underwent gait training followed by a 10-meter walkway. Finally, they took a rest for 2 minutes. Step 2: This procedure was repeated 2 times. The inter line distance was kept 110% of the baseline step length. The interline distance was gradually increased to 120%, 130%, 140% of baseline step length in 2nd 3rd and 4th week, respectively. These steps were performed for a duration of 20-30 minutes per session, once a day, five days a week, for four weeks.[13] Conventional Physiotherapy includes active or passive ROM, Stretching, Balance activities, Resistance training, Practice of functional activities and transitional movements.[14]

Figure 2. Gait Training with Auditory Cue and Visual Cue

Figure 3 Consort flow diagram



STATISTICAL ANALYSIS

Data of 30 subjects were analyzed using statistical package for social science version 29 (SPSS V.29) and Microsoft excel-2010. Level of significance was at 5% and confidence interval (CI) at 95%. Before applying statistical tests, data was screened for normal distribution by using Shapiro–Wilk test, which was published in 1965 by Samuel Sanford Shapiro and Martin Wilk. As data was distributed normally for each outcome measures which are step length, stride length, cadence, velocity and POMA-G so parametric tests Paired t-test was applied for within group and between group analyses.

RESULT

The present study was conducted to study the effectiveness of visual cues and auditory cues on gait parameters in individuals with Parkinson's disease. Total 30 Parkinson's patients were included in the study out of which 15 subjects were the part of visual cues who received visual cue & conventional physiotherapy and other group included 15 subjects who received auditory cues & conventional physiotherapy. Pre-post 4 weeks data of step length, stride length, cadence, velocity and POMA-G were taken. Demographic data were age, gender, height, weight, onset, LLD, MMSE and MHYS which descriptive data shows in below table.

Table 1: Descriptive Statistics of the Participants

DEMOGRAPHIC DATA	AUDITORY CUE GROUP Mean ± Std. Deviation	VISUAL CUE GROUP Mean ± Std. Deviation
AGE	69.20 ± 5.78	68.40 ± 6.34
HEIGHT	160.80 ± 5.68	160.93 ± 11.68
WEIGHT	63.27 ± 7.17	63.73 ± 10.41
ONSET	60.07 ± 5.04	63.07 ± 8.35
LLD	89.53 ± 5.68	89.93 ± 7.07
MMSE	29.53 ± 0.83	29.73 ± 0.70
MHYS	1.83 ± 0.86	2.47 ±1.03

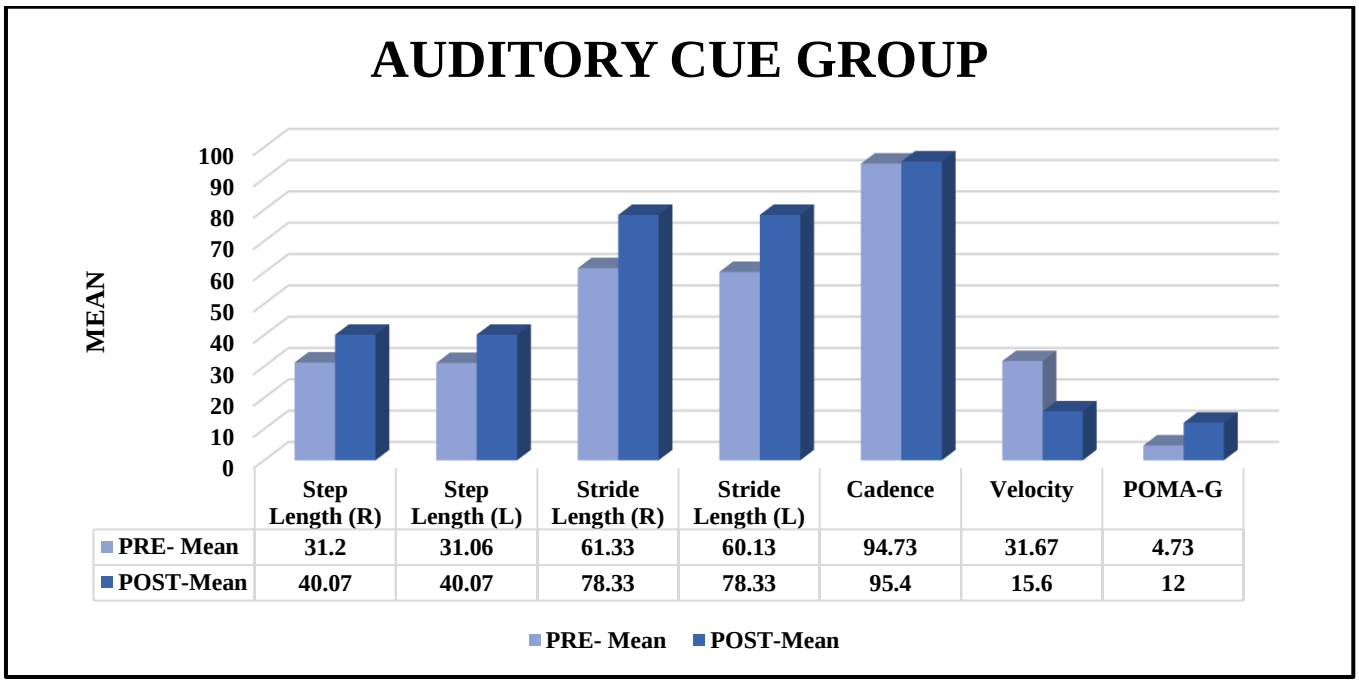
Table 2: Gender Distribution of Participants in Both Groups

GROUPS	GENDER	FREQUENCY	PERCENT
AUDITORY CUE	Male	7	46.7
	Female	8	53.3
	Total	15	100.0
VISUAL CUE	Male	10	66.7
	Female	5	33.3
	Total	15	100.0

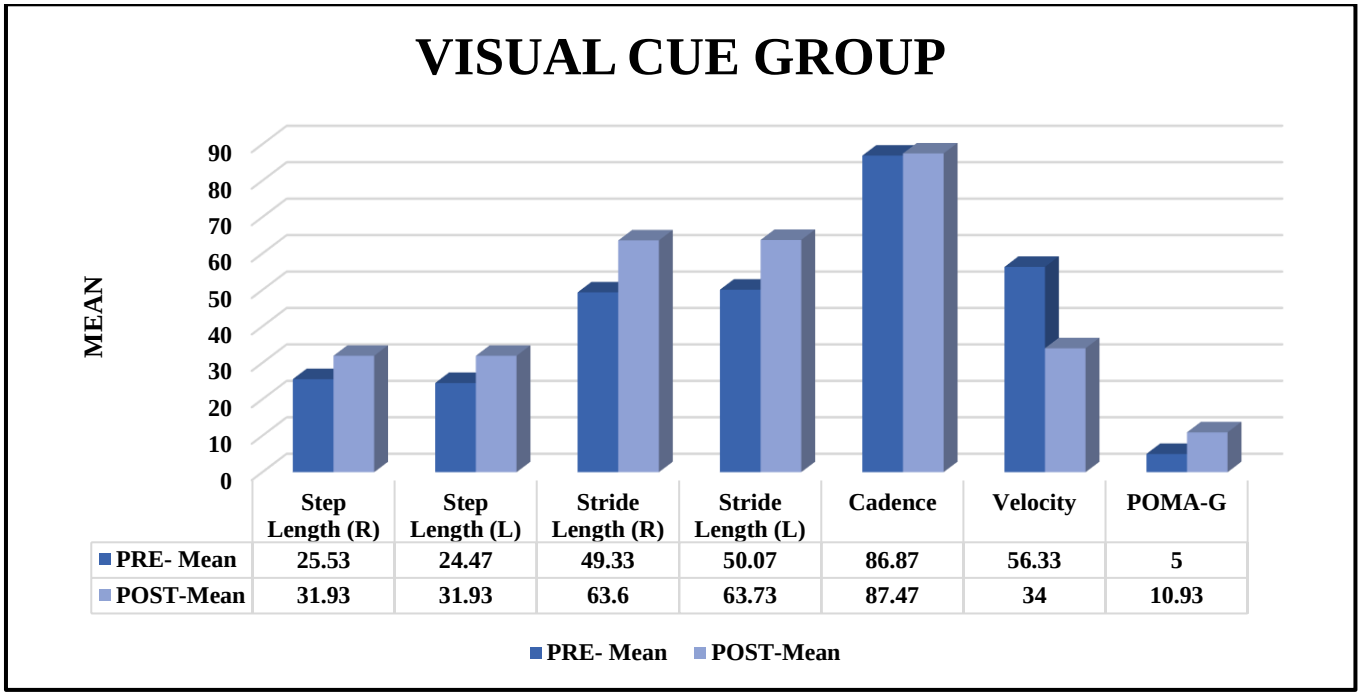
Paired t-test was applied for within group analysis. *p*-value < 0.05 were considered significant. In both the groups, result shows there are statistically significant difference within group analysis in step length, stride length, velocity and POMA-G but no difference was found in cadence. Independent t-test was used for between group analysis of both the groups for step length, stride length, cadence, velocity and POMA-G. Result shows there are statistically significant difference in between group analysis in POMA-G, but no significant result was found in step length, stride length, cadence and velocity. (R: Right side, L: Left side)

Table 3: Pre-Post Mean and Standard Deviation with Statistical Analysis (Within Group Comparison of Both the Groups)

Auditory Cue Group				
OUTCOME MEASURES	**PRE**	**POST**	**t-test**	***p*-value**
	Mean ± Std. Deviation	**Mean ± Std. Deviation**		
Step Length (R)	31.20 ± 5.88	40.07 ± 4.92	10.042	< **0.001**
Step Length (L)	31.33 ± 5.79	40.07 ± 4.92	10.039	< **0.001**
Stride Length (R)	61.33 ± 12.48	78.33 ± 10.00	11.511	< **0.001**
Stride Length (L)	61.13 ± 12.03	78.33 ± 10.00	12.128	< **0.001**
Cadence	94.73 ± 9.96	95.40 ± 7.94	0.276	0.786
Velocity	31.67 ± 7.29	15.60 ± 3.74	9.482	< **0.001**
POMA-G	4.73 ± 1.22	12.00 ± 0.00	23.016	< **0.001**
Visual Cue Group				
OUTCOME MEASURES	**PRE**	**POST**	**t-test**	***p*-value**
	Mean ± Std. Deviation	**Mean ± Std. Deviation**		
Step Length (R)	25.93 ± 10.35	31.93 ± 11.01	4.954	< **0.001**
Step Length (L)	24.47 ± 11.99	31.93 ± 11.01	4.265	< **0.001**
Stride Length (R)	49.33 ± 22.04	63.60 ± 22.06	4.327	< **0.001**
Stride Length (L)	50.07 ± 21.54	63.67 ± 22.05	4.148	< **0.001**
Cadence	86.87 ± 14.64	87.47 ± 5.32	0.182	0.858
Velocity	56.33 ± 59.80	34 ± 31.57	1.779	**0.011**
POMA-G	5.00 ± 1.25	10.93 ± 1.10	13.439	< **0.001**



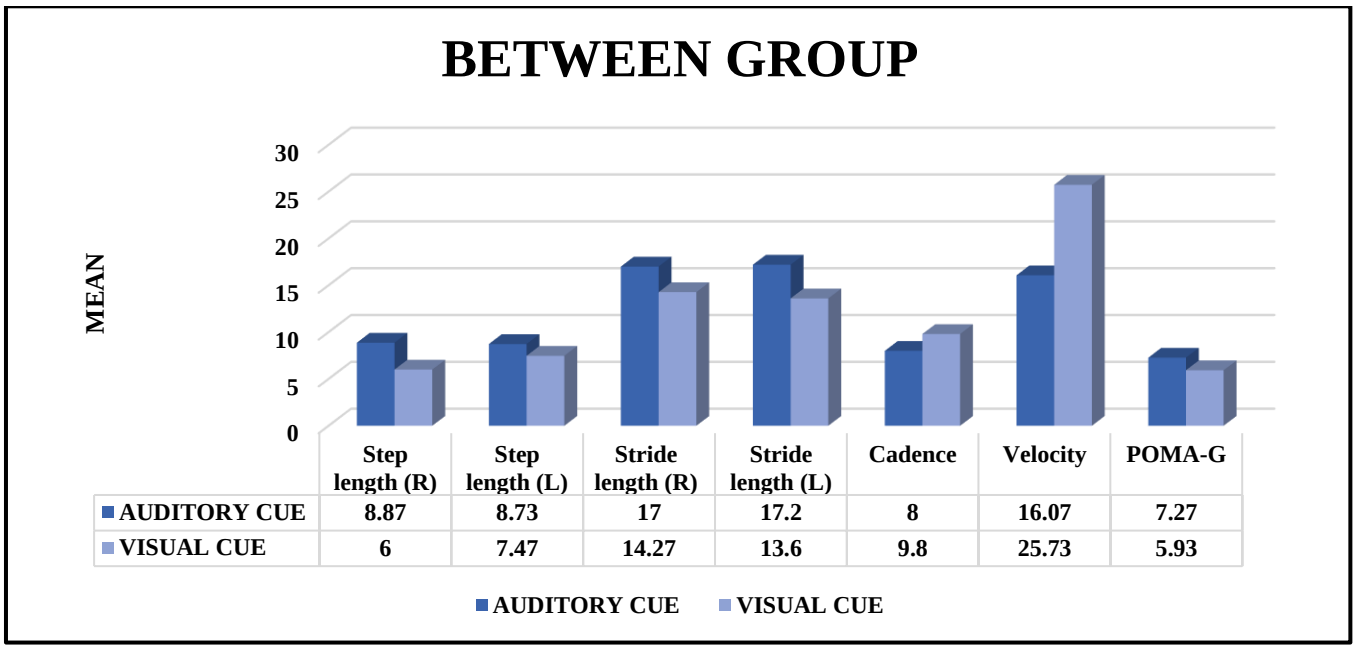
Graph 1: Pre-Post Mean Values of Auditory Cue Group



Graph 2: Pre-Post Mean Values of Visual Cue Group

Table 4: Pre-Post Mean and Standard Deviation with Statistical Analysis (Between Group Comparisons of Both the Groups)

OUTCOME MEASURES	AUDITORY CUE GROUP	VISUAL CUE GROUP	t-test	*p*-value
	Mean ± Std. Deviation	Mean ± Std. Deviation		
Step Length (R)	8.87 ± 3.42	6.00 ± 4.69	1.913	0.066
Step Length (L)	8.73 ± 3.37	7.47 ± 6.78	0.648	0.522
Stride Length (R)	17.00 ± 5.72	14.27 ± 12.77	0.757	0.456
Stride Length (L)	17.20 ± 5.49	13.60 ± 12.70	1.008	0.322
Cadence	8.00 ± 4.38	9.80 ± 7.74	0.784	0.44
Velocity	16.07 ± 6.56	25.73 ± 31.34	1.169	0.428
POMA-G	7.27 ± 1.22	5.93 ± 1.71	2.457	**0.02**



Graph 3: Pre-Post Mean and Standard Deviation of Between Group Analysis

DISCUSSION

The current study was focused on, to see the effectiveness of visual cues and auditory cues on gait parameters in individuals with Parkinson's disease. A total 30 participants were divided into two groups. Within group analysis shows there are statistically significant difference in step length, stride length, velocity & POMA-G but no difference was found in cadence in both the groups. Between group analysis shows there are statistically significant difference in between group analysis in POMA-G, but no significant result was found in step length, stride length, cadence and velocity. Mechanisms concerning that are clinically significant for RAS, Oscillatory movements synchronized to routinely paced external cues, and movements are matched to a continuously timed reference.Change in motor planning and execution, Create a stable anticipatory time scale, Improving movement quality, Facilitates execution of expected motor responses. It was proposed that RAS may alter neuroplasticity. Improving control of muscles, Reducing the variability of movement, Changes not only temporal aspects but also kinematic control of movements. Auditory stimulation primes the motor system to a state of readiness to move, which facilitates the motor response quality. The possible neuro physiological mechanism behind the improvement in visual training group could be the attention during walking as it plays major role in gait control. Stepping on the line of certain length distance improves attention along with induction in the dynamic visual flow for maintenance of locomotor pattern. As attention is improved it changes to corticalised task. The visual information converted into action is called 'visual motor process'. The sensory information received during visually guided movement reaches to dentate nucleus of cerebellum for generation of movement. This attention to visual information activates the cerebellum and basal ganglia which has reciprocal connection with brain stem and cerebral cortex for control of automatic motor process. Another mechanism responsible for the significant positive change in gait and velocity could be the visual feedback as it enhances the motor function. Due to linkage between the occulomotor and locomotor pathway there is a change in muscle co-ordination pattern which leads to controlled gait movement. Postural sway of leg decreases and the ankle movement increases to improve body control. In addition, visual movements improve accuracy and precision of foot placement.[13,15]

CONCLUSION

As result shows there is improvement in auditory cue and visual cue groups but there is no significant difference in between group analysis on gait parameters which are step length, stride length, cadence, velocity and POMA-G. It suggests that both interventions are beneficial and can be used in clinical practice easily for the patients who have difficulty in walking with low cost to therapists and patients.

LIMITATION(s)

This study has some limitations. There was a lack a lack of follow-up after completation of 1 month period to dtermine the long term effects of training for prticipants. Different types of footwear were used. Different types of floorings were used. Not all subjects were ON medication.

FUTURE RECOMMENDATIONS

1. By set the specific follow-up period, investigate the long-term effect of both cueing strategies.
2. Combined effect of both cueing strategies on gait parameters can be investigated.
3. Effect of cueing strategies can be also analyzed on gait in other neurological disorders.
4. Cueing strategies can be used on other outcomes such as balance and ascending & descending stair climbing.

ACKNOWLEDGEMENT

My sincere gratitude and appreciation go to Dr. Edrish Contractor, Dr. Khyati Shah, Dr. Dhaval Shastri, Dr. Mitesh Chandarana, Dr. Narendra Barad, Dr. Hemant Tiwari, other senior facilities and all the staff members of Shree Swaminarayan Physiotherapy College for their unwavering support. I would also like to extend my heartfelt appreciation to all my patients, family and friends.

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