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An Overview of Different Treatment Approaches to Improve Gait and Balance in Parkinson's Disease (PD): A Narrative Review

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ABSTRACT

Parkinson's disease (PD) is a progressive neurodegenerative disorder characterized by resting tremor, bradykinesia, rigidity, postural instability and gait disability. Impaired gait and balance can be severely disabling for the patient making it difficult for them to carry on with their day-to-day activities. The effects of levodopa on gait and balance are quite controversial with some studies even describing levodopa as a double-edged sword; this and the progressive nature of the disease makes exercise therapy of utmost importance for the improvement of symptoms. However, designing an appropriate exercise regime for PD patients is not an easy task given the motor learning difficulties seen in these patients. Even though a variety of exercise interventions like treadmill, balance, resistance, multicomponent training, complementary approaches, aquatic therapy, cueing, virtual reality training are being used in the PD gait and balance rehabilitation, there still exists a lack of clarity about the type, right combination, duration and intensity of exercises to be used in order to help the patient achieve maximum results. This narrative review will evaluate different exercise approaches used in the gait and balance rehabilitation of PD patients and in the end the potential ways to improve upon the current practice will be discussed.

Keywords: Parkinson's disease, gait, balance.

INTRODUCTION

Parkinson's disease (PD) is the second most common neurodegenerative disorder after Alzheimer's disease. It has got a prevalence rate of about 1% at age 65 which rises to about 5% by the age of 85.[1] India is home to nearly 0.58 million persons living with PD as estimated in 2016.

PD is caused due to degeneration of the dopaminergic neurons of the substantia nigra. [1] It is characterised by bradykinesia, rigidity, tremor, motor learning difficulties and postural instability and gait disability (PIGD).[1,2,3] Clinically PIGD appears to have several components - Postural instability with falling (PIF) and freezing of gait (FOG) are the most prominent ones. (FOG) is one of the most disabling symptoms which affects more than one third of individuals with PD. It is a common cause of falls, dependency and poor quality of life.[2] The effects of Levodopa on improving motor learning deficits, gait and balance functions in PD is quite ambiguous. Studies

have shown that only certain aspects of gait like stride length, gait speed and double support time variability are responsive to Levodopa. Cadence and other temporal aspects of gait are levodopa resistant. The effects of Levodopa on certain aspects of motor learning and balance are even more disappointing. It has been found that Levodopa induced dyskinesias increased Postural instability.[4,5] All the aforementioned reasons make exercise therapy and motor training one of the most promising current options for improving the symptoms.

Exercise has been widely used in allied health care for PD to address symptoms and improve motor functions, following are the different exercise interventions –

1. **Gait training -** It can be given in the following ways - Treadmill walking, body weight support treadmill training (BWSTT), Cued treadmill training, Robot assisted treadmill training. [5, 6, 7, 8, 9, 10, 11]
2. **Balance training -** (highly challenging goal-oriented balance exercises given in a progressive manner, strengthening, ROM, anticipatory & reactive balance activities, gait training, modified Wing Chun, balance dance and square stepping. [12, 13, 14, 15, 16]
3. **Resistance training -** (PRE for trunk and Lower limb - using body weight/cuffs/theraband, toe/heel raises). [17, 18]
4. **Multicomponent training -** which includes different combinations like walking and turning plus treadmill training, perturbation plus treadmill training, cued multimodal balance training, resistance training on unstable surface. [19, 20, 21, 22]
5. **Virtual reality -** Virtual reality is a computer-generated simulation of a three-dimensional image or environment. That can be interacted within a seemingly real or physical way by a person using special electronic equipment, such as helmet with a screen inside or gloves fitted with sensors. Image realistic model on computer VR games (auditory and visual stimuli), indoor/outdoor VR balance training system, virtual reality in combination with treadmill training. [23, 24, 25]
6. **Aquatic therapy-** It can decrease muscle tone, reduce spasm severity, as well as increases functional mobility. It can also improve balance and coordination in individuals who fear an increased risk of falling. Aquatic therapy reduces the amount of gravity on a person, alleviating them to move more. With less pain and pressure on their joints and muscle. [26, 27]
7. **Complementary therapy –**
   Qigong: It is a promising rehabilitation method which integrates mind and body movement and is a useful treatment for neurodegenerative diseases. It enhances exercise tolerance and improves balance. [28]

Taichi: It is known to reduce the risk of falls as it enhances proprioception and fitness of an individual. It is being used for health benefits and meditation. [29]

Tango: it included deep breathing exercises, trunk rotation and moving neck side to side, walking in a circle, side bending stretch and bending over to touch knee [30]

Yoga: It connects mind and body which involves multiple systems to improve balance in PD patients. It includes stretching which lengthens the muscle groups to improve flexibility and relaxation techniques along with meditation to calm and sooth the mind. [31, 32]

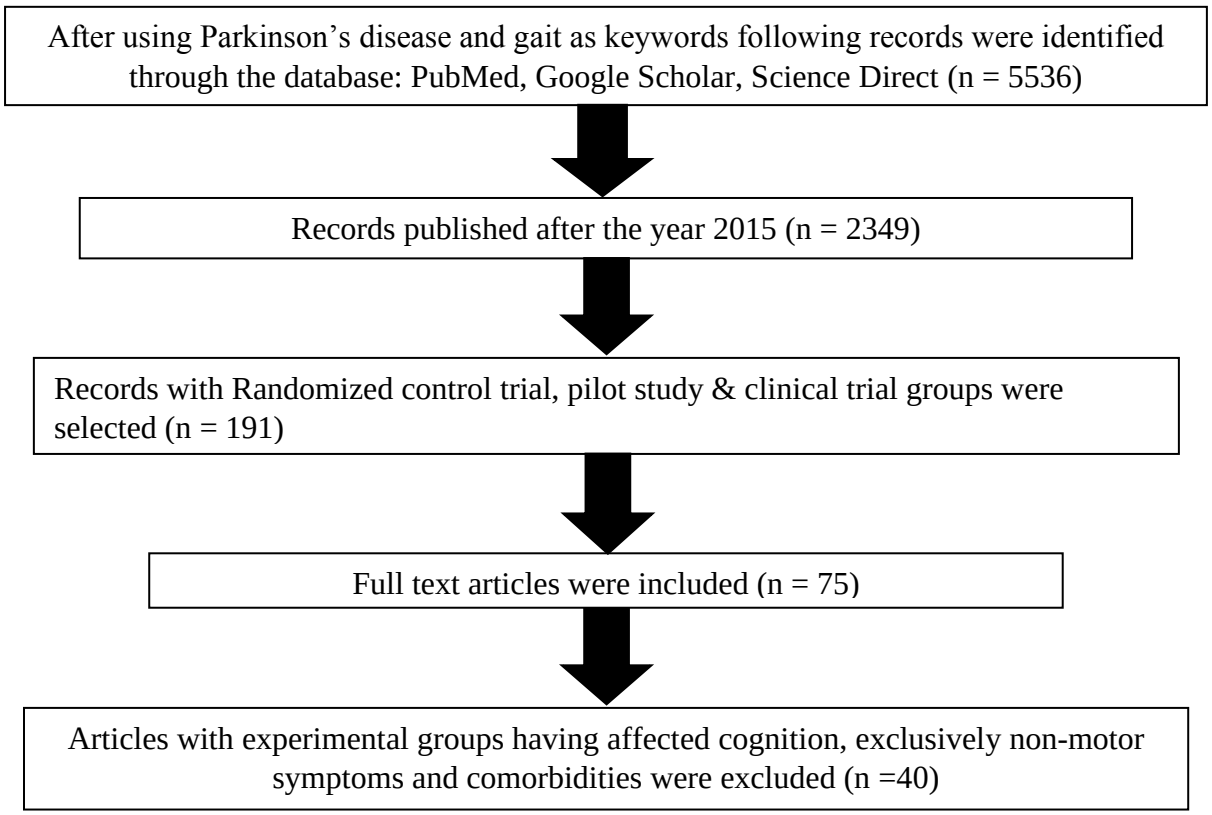
However, the lack of comprehensive, effective exercise guidelines, specifically focusing on gait function, makes it reasonable to evaluate the efficacy of a variety of exercise modalities and programs. [28, 29, 30, 31, 32] The purpose of this narrative review is to provide an overview of different exercise approaches used to improve gait and balance in PD patients, to

shed light on virtual reality training and its impact on the above.

Rationale

PD being a progressive degenerative disorder, the symptoms are bound to worsen overtime. Research has shown that pharmacological treatments have got limited to negative effect on gait and balance. This makes the understanding of the efficacy of different exercise approaches used along with pharmacological treatment a necessity. [3, 4] Learning difficulties seen in these patients have a huge impact on the therapy results making it necessary to devise strategies that best circumvent these difficulties. Therefore, it seems necessary to carry out a review of literature in order to evaluate the strength of evidence to inform clinical practice. Under these circumstances this narrative review aims to summarize and assess all the currently available exercise interventions used in the rehabilitation of PD.

MATERIALS AND METHODS



Keyword searches within the PubMed database were used to identify articles of interest. Only articles written in or translated into English with full text available were considered. Within section effect of training on Postural Instability in Gait disorders (PIGD) were made. For "Parkinson's disease" + "gait" or "balance". Articles that applied a specific non-pharmacological treatment or treatment involving training or therapy or training with quantitative measures of over ground gait and / or standing balance changes as primary outcome measure were selected. Only Randomized control trial, clinical trial and pilot study were considered which were published after year 2015. Full articles of selected abstract were then read to ensure relevance. While training methods, intensity and durations varied too widely for statistical comparison, studies were analysed and compared.

RESULT & DISCUSSION

Table 1

Therapy type	Sample size	No of Weeks	Sessions per Week	Duration of each session	Treatment Given	Control / Comparison Group
Gait training	35 [8] 60 [10]	6 [8] 4 [10]	5 [8] 4 [10]	30 MINUTES [8,10]	BWSTT [8,10,]	Unsupported TT [8] Conventional gait training[10]
	50 [7] 23 [11]	8 [7] 5 [11]	5 [7] 2-3 [11]	20 -40 MINUTES[7, 11]	Cued TT [7, 11]	TT without RAS [5] TT without visual cues [11]
	96 9	4 9	5 9	45MINUTES 9	Robot assisted TT [9]	Treadmill training [9]
Balance, Resistance training	30-40 17, 18	7-8 17, 18	2 17, 18	60 MINUTES 17, 18	Resistance training [17, 18]	Balance training (Stance and gait tasks) [17, 18]
	20 -100 12, 13, 16	8-12 12, 13, 16	1-3 12, 13, 16	60-120 MINUTES 12, 13, 16	highly challenging BT (strengthening + ROM + Anticipatory & reactive balance activities, altering sensory input + gait training + modified Wing Chun + balance dance) [12, 13, 16]	Usual care [12, 13], Upper limb exercises [16]
	38 14	4 14	2-3 14	45 minutes 14	mobile platform + stretching [14]	Balance exercises + stretching [14]
	28 15	8 15	2 15	60-70 Minutes [15]	PRE (flexors & extensor muscles of LL) [15]	Usual physical activity [15]
Multi component training	24 [20]	4 [20]	5 [20]	60 minutes [20]	Walking & turning + TT [20]	TT alone [20]
	43 [21]	8 [21]	2 [21]	40 minutes [21]	Perturbation + TT [21]	TT alone [21]
	35 [22]	5 [22]	2 [22]	45 minutes [22]	Multimodal BT + RAS [22]	multimodal BT [22]
	39 [19]	12 [19]	12 [19]	50minutes [19]	Resistance + Instability [19]	PRE [19]
Complimentary therapy (Qigong,	52 [28]	12 [28]	4 [28]	60 MINUTES [28]	10 movements selected from health Qigong health qigong 12 step Daoyin Health perseveration exercises [28]	Routine stable drug treatment maintained without any other intervention [28]
	30 [31] 27 [32]	8 [31, 32]	2 [31, 32]	60 MINUTES [31, 32]	Controlled dynamic postures connected to specific breathing patterns. Modified yoga postures in sitting,	Continue with ongoing therapy [31, 32]

Yoga,					standing and supine position. Pranayama and Dhyana end with 10 minutes of Shavasana [31, 32]	
Taichi, Tango)	45 [29]	16 [29]	2 [29]	60 minutes [29]	First 8 movement of yang style short forms exercise focusing on the reduction of base of standing support, body and trunk rotation, reciprocal arm movements and controlled breathing [29]	Qigong meditation that is meditation in stillness [29]
	74 [30]	12 [30]	2 [30]	60 MINUTES [30]	Deep breathing exercises, trunk rotation, moving neck side to side, walking in a circle, side bending stretch, bending over to touch knee [30]	-----
Aquatic Therapy	30 [26, 27]	10 [26, 27]	2 [26, 27]	45 minutes [26, 27]	Physical therapy Under water and on Dry land [26, 27]	Dry land therapy [26, 27]
Virtual Reality	28 [23] 23 [24] 37 25	12 [23] 6 [24] 4 [25]	5 [23, 24] 3 [25]	45 minutes [23] 50 minutes [24,25]	(Visual stimuli) Image realistic model on computer VR games (Auditory Stimuli). [23] Basic learning -Static posture maintaining, Dynamic weigh shifting, Indoor outdoor VR balance training system. [24] Treadmill training gait training with VR [25]	Conventional Physical therapy [23, 24, 25]

Table 2

Therapy type	**Results showing improvement**	**Results not showing improvement**	**Result at follow up**
Gait training	6MWD, BBS, UPDRS 3, NHP energy, physical and pain score, FIS, FSS, walking distance, LOS total score , POMA , mediolateral index ,FGA , FES , gait quality index , fronto centro parietal /temporal electrode connectivity , TUG , endurance , FOGQ , PDQ -39. [7,8,9,10,11]	10MWT, speed of gait, turning, stride duration, cadence. [7,8,11]	No follow up
Balance, resistance training	FAB scale, PDQ-39 [17], BESTest scores, FES -I [12, 18], mins of brisk walking, overall physical activity [13], Index of stability, BESTest , Gait speed , FES-I , PDQ - 8 [14] , Mini BESt , BBS , UPDRS -part 3 [22] , TMWT , PDQ 39 , static post urography [15] , BESTest , gait speed , dual task TUG [16]	Gait velocity [17], FES-I , TUG , FOG Q , UPDRS -part 2 [22] , UPDRS -motor , FOG Q [15]	Resistance training over BT to improve postural control [17] , Balance specific &task driven BT > RT in improving postural control [18] , Progressive ,goal oriented BT + strengthening exercises improved balance , fall reduction , reduced fear of falling [12] , Intervention effects returned to baseline at 12m follow up [13] , Challenging balance tasks (without gait training) --> considerable gait enhancement [14] , At 6 m f/u effects retained only in RAS group [22] , At 12 m f/u - task specific BT enhances balance & dual task gait

			performance
Multi-Component training	UPDRS - M, BBS , TUG , 10MWT , 6MWT , qualitative and quantitative aspects of gait (walking speed , endurance) , fall rate [20] , Gait speed , 2MWT , TUG reactive postural control sub scores [21] , mobility , motor signs (UPDRS) , cognitive impairment (MoCA) , QOL (PDQ-39) [19]	-------	no difference b/w RT and RTI groups for any outcomes at post training [19], muscle strength improved in both [19]
Complimentary therapy (Qigong, Yoga, Taichi, Tango)	Gait kinematic parameters improved, TUG scores improved, QOL scores, FGA score increased [28]	No difference in gait speed [28]	-------
	ABC score improved (balance), PFS-16, score improved (fatigue), PDQ improved (quality of life) [31, 32]	FMS and FCS scores did not significantly improve (falls) [31,32]	--------
	FMS scores were slightly increased (fall prevention in elderly and friar individuals) 29	UPDRS score did not significantly increase, Taichi did not improve gait initiation, gait performance, or reducing parkinsonian disability [29]	-------
	Tango – backward velocity, timed walking distance Treadmill – forward and backward velocity Stretching – backward velocity in gait and motor function [30]	No changes in PDQ scores (quality of life) 30	-------
Aquatic Therapy	Pain, static and dynamic balance [26, 27]	Tinetti falls efficacy scale [26, 27]	There was a short follow up The conclusion is Physical exercise performed in water is more effective than in dry land [26, 27]
Virtual Reality	BBS, TUGT, UPDRS3, FGA in experimental and control group [23, 24, 25]	UPDRS 3 [23, 24, 25]	No F/u taken. Short term virtual reality > conventional PT to improve gait and balance [23, 24, 25]

Different therapy types, its duration and its effects are shown in table 1 and 2

Exercise Mode

Our results indicate that variations in the magnitude of gait and balance improvement may depend on the types, duration and intensity of training. Gait and balance parameters appear to be improved by –

1) Gait Training. [5, 6, 7, 8, 9, 10, 11]
2) Balance and Resistance Training.[12, 13, 14, 15, 16, 17, 18]
3) Multicomponent Training. [19, 20, 21, 22]
4) Complimentary Therapy (Taichi, Yoga, Qigong, Tango). [28, 29, 30, 31, 32]
5) Aquatic Therapy. [26, 27]
6) Virtual Reality. [23, 24, 25]

Treadmill Training

A large number of studies regarding the effects of therapy on gait and balance have been related to the use of treadmill therapy. Improvements in gait speed, stride length, and symptomatic scales have been noted both immediately and in the long-term following treadmill therapy. Adverse events were not observed within these studies, and patients were able to achieve a high-intensity of training. [34, 35] However, Myers et al. found that, while treadmill therapy, tango dance, and guided stretching all improved walking velocity and stride length, there was no difference between the three groups. Modifications of treadmill training like body weight supported treadmill training stimulates activity dependent neural plasticity. Evidence suggests that exercise induced motor improvements are related to mechanisms of neural plasticity. [6] Steib et al reported that perturbation TT is not superior to conventional Treadmill training and that the effects produced after training were rather small and nonpermanent. This maybe because training for 8 weeks, twice weekly might not have been sufficient to provide long lasting effects. [11] The above study suggests that technical developments should aim at exploring the optimal nature and intensity of perturbations to stimulate neural plasticity mechanisms. However, it has been shown that patients with PD who are provided with cued gait training don't retain the obtained clinical improvement after 3 months, probably due to progression of neurodegeneration and impaired implicit learning. [33] Treadmill walking has been found to produce lasting, positive effects on different gait parameters by bringing about change in specific neuroplasticity mechanisms within complex cortical-BG-cerebellar networks. [5] The addition of body-weight support makes training at high intensity possible. This helps to increase the effect of treadmill therapy. [6, 8] Research on the effects of different percentages of BWSTT in PD found that unsupported TT group demonstrated significant improvement only in BBS and Nottingham health profile emotional sub scores whereas 10% and 20% BWSTT groups demonstrated significant improvement in 6 MWT , UPDRS - motor score , NHP pain sub scores and fatigue after training . 20% BWSTT provided the highest improvement in balance and fatigue relief. [6] However the follow-up period was short for understanding the maintenance of the training effects. [6] Studies have shown that trunk exercises also improve gait symmetry. [33] Cueing also appears to improve results of treadmill training. [5, 34, 35] Studies have reported that gait speed and stride length had increased in both groups (TT and TT + visual cues) . However at two months follow-up , patients who underwent the combined training sustained better results in gait speed and stride length and sustained the improvement in the Timed Up and Go Test . Training had spanned for 5 weeks with a total of 12 sessions (20-45mins). [5, 11] Evidence suggest that RAGT could be a valuable tool in improving gait ability and motor performances in patients with PD, with long-lasting effects. After 4 weeks training (1 hour session) both groups showed improvements in walking ability (gait speed, walking capacity) and these effects were also preserved at 3 months follow up. [36] Only those patients undergoing RAGT maintained their functional motor

gain at three-month follow-up, potentially indicating the superiority of intensive RAGT vs. over ground gait training, together with conventional exercise program. [7, 10]

Balance and Resistance Training

Group of studies have shown that 4 -12 weeks of highly challenging task-oriented balance training which included strengthening + ROM + anticipatory and reactive balance activities, altering sensory input + gait training led to significant improvements as seen on mini BESTest, FES-I, Index of stability, PDQ-8. [12, 13, 14, 16] However, intervention effects returned to baseline at 12 months follow up. [13] Study conducted by Schlenstedt et al reported that there was no significant difference between BT and RT groups at 8 weeks follow up following a 7 weeks training. It is to be noted that participants from the RT group and not from BT group significantly improved on the FAB scale mostly due to improvement of rate of force development and stride time variability. However, the sample size was small for the generalisation of results. [17] Study conducted by Sparrow at el used Horak's theoretical balance framework for PD. The research protocol consisted of exercises focussing on 6 interacting systems contributing to balance control which included strengthening, range of motion, anticipatory and reactive balance activities, altering sensory input and gait training. Exercises were given in a progressive manner. [12, 37] Study reported that a highly challenging, and progressive exercise program was effective in reducing falls, improving balance, and reducing fear of falling in persons with mild-to-moderate PD. [36] Results revealed that the training effects were not preserved for a long duration – thus confirming the need for sustained participation. [12, 13, 38] Studies have reported that 8 weeks of multidimensional balance training showed more significant improvements than control group (upper limb exercises) in BESTest total and subsection scores, gait speed and dual-task TUG time. At both 6 months and 12 months follow up, experimental group showed significantly greater gains than control group in BESTest and dual task Timed Up and GO test (TUG). The effects of 8 weeks of PRE improved speed of fast rhythm walking and patient perceived quality of life. It had no effect on MDS – UPDRS. [15]

Multicomponent Training

Bang et al reported that after 4 weeks of walking plus TT there was significant improvement in the UPDRS -M, BBS, TUG, 10MWT and 6MWT as opposed to the conventional gait training group. It was also found that the fall rate changed from 83% to 67% in the EG. The small sample size and short follow up period prevents the generalisation of results. Steib et al suggested that 8 weeks of perturbation TT showed improvements in gait speed, 2MWT, TUG, reactive postural control sub score. However, perturbation TT cannot be considered superior to conventional TT as the effects produced after training were rather small and nonpermanent. This may be because training for 8 weeks, twice weekly might not have been sufficient to produce long lasting effects. [21] Studies have reported that 4 weeks of walking and turning plus treadmill training showed significantly more improvement than the conventional training plus treadmill training group in the UPDRS-M, BBS, TUG, 10 MWT, 6 MWT and fall rate changed from 83% to 67%. [20] Studies have shown that patients in early to mid-stages of PD immediately adapted their gait patterns during a single session of perturbation and treadmill training walking and that these were transferred to over ground walking. However, the effect was not permanent. [21] Studies have shown that exercise interventions with high motor complexity may help to alleviate deficits in mobility, motor signs, and cognitive impairment of patients with PD. [19] Evidence suggest that both groups (balance training plus rhythmic auditory stimulation and BT without RAS) improved significantly on MINI BEST scores, without differences

between both interventions' modalities. However, at 6 months follow up the effects were retained only in the RAS supported intervention group thus signalling towards the clinical significance of cueing in motor training of PD patients.

Complimentary Therapy

YOGA is a traditional method that helps to connect the mind and body. Research suggests that it can help to improve balance. Evidence has shown that there was significant improvement in the motor function following yoga intervention as seen on Mini BESTest score and FGA score. [31] Study also shows that yoga intervention helps in reducing PD related fatigue level and thus helps in improvement PD specific HR-QoL scoring. [32] Study conducted by Puymbroeck et al. showed that 8 weeks of hatha Yoga significantly improved motor function postural stability, functional gait, freezing of gait. It reduced PD related Fatigue in participants. However, it did not significantly reduce the risk of falls in PD patients. [31, 32] TAI CHI is an ancient Chinese tradition that is practised as a graceful form of exercise. It involves a series of movements performed in a slow, focused manner and accompanied by deep breathing. Research has shown that Taichi is not effective in improving dynamic postural control in PD patients. [29] Amano et al studied the effects of Tai Chi exercise on gait in PD patients. Movements that were included in the exercise focused on reducing the base of standing support, body and trunk rotation, reciprocal arm movements and controlled breathing. Improvements were seen in gait initiation of few participants. There were no significant improvements in gait parameters. [29] Health QIGONG is an approach which helps to integrate mind, breath and body movement. Studies have shown that QIGONG helped in improving TUG test score, joint ROM and gait. It is effective as it improved the PD patient's ability to focus on posture and also helped to increase proprioceptive input of trunk and lower limb joints. [28] Yang et al. studied Health Qigong exercises and their effects on gait in PD patients. After 12 weeks of therapy, participants showed improvements in joint range, gait, TUG test scores and balance. There were no significant changes in gait velocity. [28] TANGO as a complimentary therapy did not produce significant improvement in the gait and balance related outcomes. [30] Tango as a complimentary therapy included deep breathing, trunk rotation, and moving neck side to side, bending over, walking in circle and side bending stretch. Study conducted by Rawson et al showed that no changes were seen in patients when tango only was used as mainstay treatment approach. [30]

Aquatic Therapy

Aquatic therapy is a type of therapy that makes use of the principles of Taichi and qigong. It involves a combination of slow rhythmic movements of the upper limb, lower limb and trunk performed while standing in shoulder depth water. Types of intervention done in Aquatic therapy may produce significant improvement in motor function, functional mobility, flexibility, fitness level (Balance), and Cardiorespiratory endurance. Studies have shown that water is supreme curative environment; warm water can have a remedial effect on rigidity. Many studies have confirmed that rigidity in Parkinson's which has a central origin is diminished with peripheral stimulus that is heat. Clinical ai chi improves motor learning in PD patients as it makes use of rhythmic patterns and constant postural adjustments. [26] As Aquatic therapy makes use of hydrostatic Pressure and flotation, greater variety of movements can be performed with greater ease and low impact. These movements are taught to the patient using verbal and visual instructions. Clinically this technique has come to be known as ai chi. Studies have shown that aquatic therapy has led to improvements in static and dynamic balance which can possibly lead to certain improvements in gait of PD patients, additionally aquatic therapy has also shown

to bring about a decrease in the pain levels of PD patients which can increase their activity participation and thus improve their Quality of life. . Studies have shown that aquatic therapy given twice a week for more than 10weeks may bring positive effects in Pain and Balance dysfunction in PD which can also improve postural instability and improve quality of life. [26, 27]

Virtual Reality

The VR- Gait system consists of VR software that generates and display a dynamic environment on a large high-definition television mounted in front of a treadmill. The treadmill is paired with an overhead suspension device that can provide the patient with partial weight support. The difficulty level of the training scenarios can be adjusted by varying the speed and slope of the treadmill and the amount of body weight support. VR being a computer-generated technology helps to improve the interaction between the virtual environment and the patient. This technology is considered a viable therapeutic modality in motor rehabilitation as it provides individuals with Parkinson's disease the opportunity to perform variety of movements without any adverse effects associated with standard therapy. [11] It also provides a simulated environment giving an opportunity to take into consideration leisure preferences of the patient. VR technology has attracted attention as a new method of rehabilitation and in recent years the literature in this area has expanded. [23] Virtual reality (VR) is promising treatment approach as it provides visual, auditory, and somatosensory stimuli to help in improving gait for individuals with PD. [23] VR technology uses various stimuli which increases the reactivity of patients. Sensory organs and Rhythmic stimulation can remunerate for the rhythm, ease muscle spasm, and improve the instability of centre of gravity placement. VR technology can be applied to the field of rehabilitation to overcome the shortcomings of traditional approaches and saves manpower. VR is the combination of games and treatments, that is, the screen provides an artificial scene that makes the patient feel like being in a game or travel environment, making the treatment process full of fun and improving the patient's optimism. Different task given in VR for Basic learning and indoor are star excursion, home yoga for Static posture maintaining. Ball maze, table tilt, cooking, cloth washing and outdoor activities like Car racing, park walking and apple catching for dynamic weight shifting. The visual feedback allows the patient to sense their own position and movement direction in the space based on visual tracking and to coordinate their body position. [23] VR improves the cognitive abilities of the PD patient by providing three types of feedback–somatosensory, auditory and visual. [23, 39] VR training is different from other approaches as it gives the patient the opportunity to explore environments other than the home and hospital environment. [40] VR integrate the principle of motor learning while also contributing attractive, challenging training in complex environment. The multisensory response leads to development in motor learning through problem solving and multiple repetitions of movement. [23, 40]

CONCLUSION

Our study shows that irrespective of the type of therapy, it is the duration of the therapy and regular follow up that helps in producing long term effects in PD as procedural learning is partially impaired in PD patients. On the basis of above findings, exercise approaches focusing on multiple components (gait, balance, strength, ROM and flexibility) coupled with cueing, virtual reality and longer duration yield better results than conventional therapy focusing on just one aspect. Since PD is a chronic progressive disease, we suggest that longterm VR training with follow up should be combined with treadmill training/ balance / resistance / multicomponent training / complimentary approaches/ Aquatic therapy to maximize the result of

therapy. Further research should be done on Virtual Reality training to know about its efficacy in Parkinson's disease.

Studies on motor learning have shown that PD patients are capable of motor learning, however it takes place in a slow pace. Before framing any exercise, guideline this should be taken into consideration. PD patients mostly rely on feedforward type of learning as they find it very difficult to make adaptations on the basis of feedback received. Gait and balance are subject to constant changes and therefore can't be mastered in a feedforward manner. Therefore, the primary Aim of the therapy should be to subject the patient to as much simulated environments and situations as possible and to also ensure that these learnt skills are generalised successfully.

Evidence has shown that therapies aimed at improving factors related to gait and balance and making use of cognitively challenging exercises are more productive that regular exercises. Hence, it's advisable to provide the patients progressively challenging and goal directed tasks than random activities. The training should last for more than 12 weeks with regular follow ups. Each session should focus on repetitions and on making the patient aware of his/ her movement patterns, for these therapies must attempt to incorporate additional feedback (possibly in the form of verbal prompts, rhythmic auditory cues, visual cues and Virtual reality systems).

Results suggest that virtual reality training and other cueing methods have a huge impact on the training process and therefore it must be combined with treadmill/ balance/ resistance/ other training methods to maximize the results. Aerobic training using body weight support is also highly recommended. This training approach combined with VRT can be of great significance as it improves both motor as well as non-motor symptoms like fatigue, pain thus improving the overall QOL of the PD patient. Currently the exercises prescribed are largely variable. Addition of more evidence-based research in the field will help to determine the best potential options based on patient's profile.

Declaration by Authors

Ethical Approval: Not Applicable

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