

Novel Rehabilitation Techniques for Fall Prevention in Parkinson's Disease: A Review of Recent Evidence.

Abstract: Recurrent falls are a common phenomenon in Parkinson's disease (PD) patients which leads to increased healthcare costs, poor quality of life, and caregiver burden. With timely detection and suitable exercise training fall in patients with Parkinson's disease can be prevented or minimized. This review aims to provide distinct recent information of different intervention strategies to prevent falls in PD. Article searched in electronic data base like PubMed and Scopus indexed journals from the past five year to retrieve recent evidence. using keywords such as Parkinson's disease, fall prevention and rehabilitation. Only Systematic review and RCT were added for the higher-level evidence data extraction. Various mechanism behind the fall in PD as well as worsening of the symptoms as the result of disease progression may be the reason behind the negative results of some of the intervention. However, exercise-based program and Tai chi found to have positive evidences for preventing falls in PD patients.

Keywords: Parkinson's disease, fall, fall prevention, rehabilitation, physical therapy

Introduction

Parkinson's disease (PD) is a progressive and disabling degenerative disorder that is characterized clinically by bradykinesia, tremors, rigidity and postural instability with the major pathology being the progressive damage of dopaminergic midbrain neurons in the substantia nigra. The incidence and prevalence of PD increases with advancing age with approximately 7 to 10 million people being diagnosed with PD globally. ^[1, 2]

Based on level-1 evidence on recurrent falls in PD, 35% to 90% of patients had a singular episode of fall during the reporting periods. This leads to increased healthcare costs, poor quality of life, caregiver burden, morbidity, and mortality. ^[2,3] Falls in PD are associated with prior fall history, rigidity, impaired executive function, pathological cholinergic function, medications, motor response fluctuations and freezing of gait. ^[2, 4]

Rigidity is one of the main characteristics of a PD patient. Rigid patients lack the capability to endure perturbations to the centre of body mass due to increased muscle stiffness. ^[5] Delayed neuro-musculoskeletal system response is seen as the stiffness of the hip joints is amplified beyond a definite amount. This makes it increasingly challenging to maintain balance without incorporating stepping strategies during perturbations. Additionally, some recent studies highlighted axial rigidity as another contributing factor for fall in PD. Since lower limb rigidity could impair anticipatory postural control adjustments and stepping reaction time in PD, this could consequently cause falls. ^[1, 5-7]

Acetylcholine (ACh) is predominantly important for control of mobility, which is comparatively less in patients with PD to age-matched, healthy controls. Sustained attention and executive function are correlated with ACh. Higher incidence of falls is noticed in patients with PD who have reduced thalamic acetylcholine esterase. ^[8] Compromised attention increases difficulty with performance of concurrent tasks which may contribute to falls, hindering the performance of compensatory movements to avoid a fall. ^[9,10] Anticholinergic medications, commonly used in PD to treat both motor and non-motor symptoms, also contribute to reduced cholinergic activity in addition to the cholinergic reduction due to PD pathology. The sedative effects of certain medication like antidepressants and antipsychotics use have also been associated with falls. ^[10, 11]

The 'Basal Ganglia (BG) – Supplementary Motor Area (SMA) circuit' for self-initiated movements declines internal cueing and central driving to the motor cortex in PD. A motor set disparity between the cortically selected step size and that maintained by BG is seen in advanced PD due to physiological malfunctioning. Skilled movements like gait become gradually compromised due to impaired automaticity. ^[12, 13]

Like falls, Freezing of Gait (FOG) is mostly seen in advanced PD. Freezing episodes generally last less than 10 seconds with the exception of few episodes that exceeds 30 seconds. With disease advancement, FOG becomes more recurrent and disabling, often leading to falls. ^[14, 15] Most FOG episodes occur commonly during turning movements, in crowded places and in time-restricted and stressful situations. Gait is automatic and requires less attention; however, impairments put more stress on voluntary mechanisms, and cognitive resources. Increasing awareness and decreasing automaticity causes FOG, which is one of the leading factors for falls. ^[14, 16, 17]

Even though with medication worsening of body functions are controlled up to an extent, people with PD who are predisposed to falls often require appropriate physical therapy rehabilitation for fall prevention and there by improve their quality of life. In the past 5 year there has been various higher levels of evidence study conducted in this aspect. Therefore, this review is done to assess and summarize the findings of all these studies and give the clinical practitioner an insight about and integrated findings related to different interventions for this scenario.

METHODS

We explored Elsevier, PubMed and SCOPUS databases specifically for Randomized Control Trial and Systematic Review (SR), since last 5 years, with an aim to find new relevant references. Included the study which available free full text. Study protocols, were excluded. Following combination of keywords used: Parkinson's disease, fall, fall prevention, physical activity and exercise.

Results

Using the keywords and based on inclusion and exclusion criteria, 6 articles were added to this review.

SI No:	AUTHOR /YEAR/ STUDY TYPE	AIM	METHODOLOGY	RESULTS
1	Fidan, O et al 2019 [18]	To find the efficacy of Tai Chi and Qigong on health-related quality of life (HRQoL) in patients with PD by extracting evidence from all the systematic reviews	Literature search done, till November 2018, to discover the systematic and meta-analyses. Databases searched: PubMed, MEDLINE, Cochrane Library, etc.,	7 studies contented the inclusion criteria and were encompassed in the study out of 1504 articles. 5 systematic reviews on Tai Chi, 2 of them were about both Tai Chi and Qigong. The study concluded no significant effect of Tai Chi and Qigong on quality of life in patients with Parkinson's disease,
2	Lai, C. H et al. 2019 Systematic Review [19]	To evaluate all systematic reviews of fall prevention exercise intervention for individuals with neurological conditions	Databases searched: Cochrane Database of Systematic Reviews, Embase and PubMed search duration: from inception to March 2018	15 studies selected out of 11 SRs or meta-analyses. (6 systematic reviews and 9 meta-analyses) were included 2 meta- results exposed that in PD participants exercise training improved balance.
3	Winser, S. J et al 2019 Systematic Review [20]	To discover the present evidence about the cost-effectiveness of exercise-based fall prevention programs for people with PD	Databases searched: Scopus AMED Allied and Complementary Medicine, PubMed, CINAHL, EMBASE, CRD, MEDLINE, EBSCO, and Web of Science Search duration: from inception to June 2019 Nonrandomized trials were included	965 were screened to include three studies involving 556 participants. Tai Ji Quan group showed reduction in falls.

4	Ashburn, A., at el 2019 RCT [21]	To evaluate the efficacy of physiotherapy for people with Parkinson's disease to prevent falls	<p>Design: RCT</p> <p>Participants: 474 PD patients (Hoehn and Yahr scale stages 1–4)</p> <p>238 were allocated to a physiotherapy training. 236 were given to usual care.</p> <p>Interventions: All participants received routine care and a single advice session at trial completion.</p> <p>Intervention group (PDSAFE): individually tailored, progressive, home-based fall avoidance strategy and balance and strengthening exercises</p> <p>Outcome: the risk of repeat falling, near-falls, falls efficacy, freezing of gait (FoG) and health-related quality of life</p>	<p>PDSAFE was not effective in reducing repeat falling across the range of people with Parkinson's disease in the trial.</p> <p>Functional tasks and self-efficacy improved and demonstrated differential patterns of intervention</p>
5	Seymour, K. C et al 2019 RCT [22]	To evaluate the effect of fall prevention strategies for people with Parkinson's (PwP) delivered by physical therapist.	<p>PD Subject who are at risk of falls with were recruited,</p> <p>474 PwP (Hoehn and Yahr 1–4) were randomised:</p> <p>238 were allocated to a physiotherapy training. 236 were given to usual care.</p> <p>Interventions: All participants received routine care and a single advice session at trial completion.</p> <p>The intervention group (PDSAFE): an individually tailored, progressive home-based fall avoidance strategy training</p>	<p>PDSAFE did not reduce falling</p> <p>Among those with moderate disease functional tasks enhanced and decreased fall rates,</p>

			<p>programme with balance and strengthening exercises.</p> <p>Outcome: the risk of repeat falling, near-falls, falls efficacy, freezing of gait (FoG) and health-related quality of life</p>	
6	<p>Morris, M. E. et al</p> <p>2017 RCT</p> <p>[23]</p>	<p>To find the effect of 6-week, home exercise program to decrease falls and disability and enhance health-related quality of life for people with idiopathic Parkinson's disease.</p>	<p>Design: RCT</p> <p>Participants: 133 PD subjects from community-dwelling.</p> <p>Intervention:</p> <p>The experimental group: - home program for 6-week. That includes falls education, progressive resistance strength training and movement strategy training.</p> <p>The control group: - non-specific life skills training for 6 weeks.</p> <p>Outcome measures:</p> <p>The Rate Of Falls, Disability And Health-Related Quality Of Life</p>	<p>The dose used in this study does not prevent falls by home program of strength and movement strategy training and falls education.</p> <p>No significant between-group differences occurred for mobility, disability or quality of life.</p>

DISCUSSION

Our Aim in this review was to assess and summarize the findings of all Systematic reviews and RCT from the last five year and provide very recent rehabilitation strategies for prevention of falls in patients with PD. Based on our search strategies around 6 articles were added in this review. The systematic reviews which we added were evaluated different treatment strategies such as Tai Chi, Qigong and fall prevention exercise intervention. One systematic review aimed to find the cost-effectiveness of exercise-based fall prevention programs We included this study since they described not only the cos effectiveness but also the treatment strategies.

The 2019 systematic review of Fidan O et al, included 7 studies. In which 5 systematic reviews on Tai Chi, 2 of them were about both Tai Chi and Qigong. Traditional Chinese medical exercises (TCMEs) comprise diverse types of exercises such as Liuzijue, Tai Chi, Wuqinxi, Qigong, Baduanjin, etc. In TCMEs Tai Chi and Qigong are the most frequently used exercises^[24]. Tai Chi, also known as Tai Chi Chuan, involves of a sequence of gentle movements and rhythmic weight shifting, combined with deep breaths and relaxation, that deliver benefits for several aspect of physical and cognitive health^[25]. Action of slow, coherent motion and rest is the steps in Qigong or Qi Gong^[26].

Previous study reported that balance, flexibility and neuromuscular coordination training were found to be enhanced with added effect on body awareness, mental attention and sense of inner peace by practicing Tai Chi and Qigong. By which this can reduce the risk of falling and to improve HRQoL^[27,28]. However, the present SR concluded no significant effect of Tai Chi and Qigong on quality of life in patients with Parkinson's disease.

Nevertheless, another SR in the same year, 2019, examined treatment effect using Tai Ji Quan. Which conducted for the duration of 10 weeks to 6 months. 556 participants where trained. intervention done initially 2 sessions per week to later one session per month, each sessions of 60 minutes. Tai Ji Quan with resistance and stretching training showed reduction in falls.

In 2019 a systematic review conducted to find the effect of fall prevention exercise intervention for individuals with neurological conditions. In which 2 meta- results exposed that in PD participants exercise, balance training, and gait training on balance, gait ability improved balance. modern study by Shen et al. (2015) showed that exercise interventions improve balance and there by decreased the fall rate in persons with PD.

Two randomised controlled trial (RCT) reported in 2019 by Seymour, K. C et al and Ashburn, A. et al to find the effect of PDSAFE in fall prevention. All domains of the World Health Organisation International Classification of Function model (WHO 2001) are addressed in PDSAFE. The programme included; a high intensity, strength and balance exercise programme (Body functions and structure domain), reinforced with strategy training (activity and participation domain), precise to the falls mechanism of the subject and delivered in home environment (environmental and personal factors domain). The strategy comprised 12 home visits to subjects with minimizing frequency over 6 months. review of any falls; warm-up exercises; review, practice and progression of individual exercise programme are involved in all session.

Both Seymour, K. C et al and Ashburn, A had a large number of samples in their study (474 participants). A personalized training programme were given to the intervention group (PDSAFE), progressive home-based fall avoidance training programme with balance and strengthening exercises. Risk of repeat falling was the The primary outcome. Which measured at 0–6 months. home visits were made by Registered physiotherapists to the participants' home to deliver 12 supervised sessions of 1–1.5 hours. However, the result of the study concluded that PDSAFE was not effective in reducing falls in a heterogeneous sample of PwP

Morris, M. E et al, conducted a RCT to find the effect of 6-week, home exercise program to decrease falls and disability and enhance health-related quality of life for people with idiopathic Parkinson's disease. Total of 133 PD subjects from community-dwelling participated in the study. The experimental group received home program for 6-week. That includes falls education, progressive resistance strength training and movement strategy training. The control group underwent non-specific life skills training for 6 weeks. The Rate of Falls, primary outcome, recorded for 12-month period immediately after the training. Disability and Health-Related Quality of Life were the secondary Outcome which assessed before and after intervention and at a 12-month follow-up. Author concluded that the dose used in this study does not prevent falls by home program of strength and movement strategy training and falls education and No significant between-group differences occurred for mobility, disability or quality of life.

Due to the variety of evaluation settings and Divergency of the interventions, a strong assumption cannot be made. More over PD is progressive neurological disorder with vast

number of pathophysiological mechanisms which contributing for the fall of the patients as discussed in the earlier. Future study should be targeting on treatment which address the individual mechanism of the fall. By then we may able to improve quality of life to this population by preventing falls.

Conclusion

For preventing falls in PD patients exercise based program and Tai ji/chi found to have positive evidences, even though PDSAFE program didn't show improvement in fall prevention it demonstrated functional tasks and self-efficacy improvement. Diverse pathophysiological mechanism and worsening of the symptoms as disease progression may be the cause behind the negative results of some intervention.

References:

1. Marsha E, Melnick. Basal Ganglia Disorders. In: Umphred DA, Lazaro RT. Neurological rehabilitation. Sixth ed. St. Louis: Elsevier Health Sciences; 2012. p. 607-619
2. Allen NE, Schwarzel AK, Canning CG. Recurrent falls in Parkinson's disease: a systematic review. Parkinsons Dis 2013;2013. <https://doi.org/10.1155/2013/906274>
3. A. Schrag, A. Hovris, D. Morley, N. Quinn, M. Jahanshahi, Caregiver-burden in Parkinson's disease is closely associated with psychiatric symptoms, falls, and disability, Park. Relat. Disord. 12 (1) (2006) 35–41. <https://doi.org/10.1016/j.parkreldis.2005.06.011>
4. Diab KS, Hale LA, Waters DL, Skinner MA. Factors contributing to postural instability in patients with idiopathic Parkinson's disease. Physical Therapy Reviews. 2014 Oct 1;19(5):302-27. <https://doi.org/10.1179/1743288X14Y.00000000148>
5. Bingham JT, Choi JT, Ting LH. Stability in a frontal plane model of balance requires coupled changes to postural configuration and neural feedback control. J Neurophysiol 2011;106(1):437–448. <https://doi.org/10.1152/jn.00010.2011>
6. Marusiak J, Jaskolska A, Budrewicz S, Koszewicz M, Jaskolski A. Increased muscle belly and tendon stiffness in patients with Parkinson's disease, as measured by myotonometry. Mov Disord 2011;26 (11):2119–2122. <https://doi.org/10.1002/mds.23841>
7. Caetano MJD, Lord SR, Allen NE, et al. Stepping reaction time and gait adaptability are significantly impaired in people with Parkinson's disease: implications for fall risk. Parkinsonism Relat Disord 2018;47: 32–38. <https://doi.org/10.1016/j.parkreldis.2017.11.340>
8. N.I. Bohnen, M.L.T.M. Muller, V. Kotagal, R.A. Koeppe, M.R. Kilbourn, S. Gilman, R.L. Albin, K.A. Frey, Heterogeneity of cholinergic denervation in Parkinson's disease

without dementia, J. Cerebr. Blood Flow Metabol. 32 (8) (2012) 1609–1617.
<https://doi.org/10.1038/jcbfm.2012.60>

9. F. Landi, A. Russo, R. Liperoti, M. Cesari, C. Barillaro, M. Pahor, R. Bernabei, G. Onder, Anticholinergic drugs and physical function among frail elderly population, Clin. Pharmacol. Therapeut. 81 (2) (2007) 235–241.
<https://doi.org/10.1038/sj.clpt.6100035>
10. Camicioli R, Majumdar SR. Relationship between mild cognitive impairment and falls in older people with and without Parkinson's disease: 1-Year Prospective Cohort Study. Gait Posture. 2010;32(1):87–91. <https://doi.org/10.1016/j.gaitpost.2010.03.013>
11. Joe J. Levosulpiride-induced neurological adverse effects: A prospective study from a tertiary care center. Annals of Indian Academy of Neurology. 2020 Mar;23(2):174.
https://doi.org/10.4103/aian.AIAN_449_18
12. Hallett M (2008) The intrinsic and extrinsic aspects of freezing of gait. Mov Disord, 23, S439-S443. <https://doi.org/10.1002/mds.21836>
13. El-Tamawy MS, Darwish MH, Khallaf ME. Effects of augmented proprioceptive cues on the parameters of gait of individuals with Parkinson's disease. Annals of Indian Academy of Neurology. 2012 Oct;15(4):267. <https://doi.org/10.4103/0972-2327.104334>
14. Chee R, Murphy A, Danoudis M, Georgiou-Karistianis N, & Iansek R (2009) Gait freezing in Parkinson's disease and the stride length sequence effect interaction. Brain, 132, 2151- 2160. <https://doi.org/10.1093/brain/awp053>
15. Schaafsma JD, Balash Y, Gurevich T, Bartels AL, Hausdorff JM, Giladi N. Characterization of freezing of gait subtypes and the response of each to levodopa in Parkinson's disease. Eur J Neurol 2003;10: 391–398. <https://doi.org/10.1046/j.1468-1331.2003.00611.x>

16. Hausdorff JM, Balash J, Giladi N. Effects of cognitive challenge on gait variability in patients with Parkinson's disease. *J Geriatr Psychiatry Neurol* 2003;16: 53–58. <https://doi.org/10.1177/0891988702250580>
17. Camicioli RM, Oken BS, Sexton G, Kaye JA, Nutt JG. Verbal fluency task affects gait in Parkinson's disease with motor freezing. *J Geriatr Psychiatry Neurol* 1998;11:181–185. <https://doi.org/10.1177/089198879901100403>
18. Fidan O, Seyyar GK, Aras B, Colak E, Aras O. The effect of Tai Chi and Qigong on health-related quality of life in Parkinson's disease: A systematic review and meta-analysis of systematic reviews. *International Journal of Rehabilitation Research*. 2019 Sep 1;42(3):196-204.
19. Lai CH, Chen HC, Liou TH, Li W, Chen SC. Exercise interventions for individuals with neurological disorders: a systematic review of systematic reviews. *American journal of physical medicine & rehabilitation*. 2019 Oct 1;98(10):921-30.
20. Winser SJ, Paul LF, Magnus LK, Yan S, Shenug TP, Sing YM, Cheing G. Economic evaluation of exercise-based fall prevention programs for people with Parkinson's disease: a systematic review. *The Journal of Alternative and Complementary Medicine*. 2019 Dec 1;25(12):1225-37.
21. Ashburn A, Pickering R, McIntosh E, Hulbert S, Rochester L, Roberts HC, Nieuwboer A, Kunkel D, Goodwin VA, Lamb SE, Ballinger C. Exercise-and strategy-based physiotherapy-delivered intervention for preventing repeat falls in people with Parkinson's: the PDSAFE RCT. *Health Technology Assessment (Winchester, England)*. 2019 Jul;23(36):1.
22. Seymour KC, Pickering R, Rochester L, Roberts HC, Ballinger C, Hulbert S, Kunkel D, Marian IR, Fitton C, McIntosh E, Goodwin VA. Multicentre, randomised controlled trial of PDSAFE, a physiotherapist-delivered fall prevention programme

for people with Parkinson's. *Journal of Neurology, Neurosurgery & Psychiatry*. 2019 Jul 1;90(7):774-82.

23. Morris ME, Taylor NF, Watts JJ, Evans A, Horne M, Kempster P, Danoudis M, McGinley J, Martin C, Menz HB. A home program of strength training, movement strategy training and education did not prevent falls in people with Parkinson's disease: a randomised trial. *Journal of physiotherapy*. 2017 Apr 1;63(2):94-100.
24. Wang YT, Huang G, Duke G, Yang Y. (2017). Tai chi, yoga, and qigong as mind body exercises. *Evid Based Complement Alternat Med* 2017:8763915.
25. Welsh M, Kymn M, Waters CH (1997). Tai Chi and Parkinson's disease. *Mov Disord* 12:137. Li F, Harmer P, McAuley E, Fisher KJ, Duncan TE, Duncan SC (2001). Tai chi, self-efficacy, and physical function in the elderly. *Prev Sci* 2:229–239.
26. Liu XL, Chen S, Wang Y (2016). Effects of health qigong exercises on relieving symptoms of parkinson's disease. *Evid Based Complement Alternat Med* 2016:5935782.
27. Jahnke R, Larkey L, Rogers C, Etnier J, Lin F (2010). A comprehensive review of health benefits of qigong and tai chi. *Am J Health Promot* 24:e1–e25.
28. Huston P, McFarlane B (2016). Health benefits of tai chi: what is the evidence? *Can Fam Physician* 62:881–890.