

REVIEW ARTICLE

IJPHY

THE NATURE OF PHYSIOTHERAPY PRACTICE TO PREVENT FALL IN PARKINSON'S DISEASE

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ABSTRACT

Background: One of the main problems in a patient with Parkinson's disease (PD) is recurrent falls. This paper aims to explore the nature of interventions which target the role of physiotherapy preventing fall in patients with PD.

Methods: A scoping review was led dependent on Arksey and O'Malley. This paper-based on this structure to perceive intervention studies have been embraced in physiotherapy to prevent fall after Parkinson disease. The search included various databases. The referencing arrangements of every pertinent paper were additionally filtered for more studies.

Results: 173 articles were included, thirty-nine of which met the eligibility criteria. Fifteen studies reported on the direct impact of physiotherapy on fall, while the rest examined the impacts of physiotherapy on factors that are associated with falls. Different outcomes, intervention types, and duration were used in these studies. Findings showed favorable results of physiotherapy on fall and near fall incidence, balance, gait, functional mobility, muscle strength and fear of falling.

Conclusion: Physiotherapy can decrease fall incidence and fall risk in people with PD. However, the heterogeneity in the patients' selection, intervention studies, outcome measures are chosen, time since the onset of disease, variation in intensity and duration of treatment between included studies makes the comparisons difficult. Consequently, more studies are needed on best intervention.

Keywords: Parkinson's disease, Physiotherapy, Rehabilitation, Exercise, Falls, Risk factors.

Received 24th July 2019, accepted 29th September 2019, published 09th October 2019



www.ijphy.org

10.15621/ijphy/2019/v6i5/186840

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BACKGROUND

Parkinson's disease (PD) is a common, exhausting, and progressive neurodegenerative disease. The elderly suffer from falls as part of the aging process, and PD patients have this as one of its complications[1].

Studies regarding the issue of falling found that those who are suffering from PD are more prone to falls compared with either healthy people of the same age or with the elderly who have other neurological conditions[2;3]. For example, a study by Bloem *et al.* (2001) [2] conducted on fall prospectively in people with PD and elderly people with good health found that PD results in a nine-fold increase in the likelihood of experiencing recurrent falls compared with healthy people of the same age. In Stolze *et al.* study (2004) [3], in comparison to patients with neurological disease "like stroke," Parkinson's patients have two times risk of falls.

The incidence rate of falls through the Parkinson's patients ranged between 38 and 87 percent [6-7]. In a study done by Hely *et al.* (2008) [4] measuring the risk of falls during 20 years of Parkinson disease, 87% of them will experience falling at least one time. It was additionally discovered that falls in PD are intermittent. For example, Pickering *et al.* (2007) [5] found that roughly 15% of individuals with this disease involvement with at least one fall each week, while different investigations announced that half of those with PD fell twice or more throughout one year. In this manner, a high number will experience the complications of falling.

Recognizing the fall risk factors is of vital importance in fall prevention. As of late, a lot of research has been directed into the reasons for falls, and a substantial number of variables have been found.

A systematic review and meta-analysis tried to summarize the evidence regarding fall risk factors in people with PD[5]. However, the authors of this meta-analysis reviewed only six fall studies and found that the most solid factor which could anticipate future falls is a history of fall. However, in spite of the fact that this factor supports the belief that fall in PD is intermittent and individuals with a previous history of fall are at extraordinary hazard and should be dealt with, this factor is not treatable in that knowing the history of fall leads to more falling can help people with PD to take preventative measures and does not show the reason for the first event of fall. Therefore, concentrating on other treatable elements related to fall is of incredible significance in the avoidance of the main fall, and should in this way be viewed as while assessing the impacts of any intervention or when designing an intervention to prevent falls. Studies exploring the reasons for falls have found different factors strongly related to falls and have recommended rehabilitation programs to focus on these components to avoid falls in individuals with PD. The most important factors include reduced balance, impaired gait, muscle weakness, poor functional mobility or performance on functional tasks, and, in addition to these physical limitations, psychological factors are also found to be risk factors[6].

Physiotherapy is one of the most important approaches to treatment for people with PD. It has continually been observed to be a viable method to alter factors, for example, balance and gait as to diminish the number of falls among the elderly[7].

Various reviews[7-10] have been done to condense the proof and to decide if physiotherapy interventions are useful for individuals with PD[However, most of these reviews did not concentrate on fall, but instead they researched the general potential advantages of physiotherapy intervention on individuals with PD to the extent that only one systematic review focused on fall. In this specific review, Allen *et al.*, (2011) [10] searched the literature up to 2009 and directed a meta-analysis to decide the impacts of physiotherapy on balance and fall rates. The pooled estimate of the impact of physiotherapy in this review demonstrated a significant enhancement in balance. However, the authors did not discover adequate proof to help or discredit the impacts of physiotherapy intervention on diminishing fall rate. In another review, Shen *et al.* (2016) [11] examined the effects of exercise training on balance, gait ability, and falls against no intervention and placebo intervention. The authors concluded that there was no evidence that training decreased the number of fallers over the short- or long-term ($p>0.05$).

Regardless of the insufficient proof given by afore-mentioned research, proof has risen out of a different review that has concentrated on the potential advantages of physiotherapy for individuals with PD, and a few advantages regarding balance and other fall-related variables have been accounted for. For instance, Authors[12;13] found that the utilization of physiotherapy gave promising outcomes, being valuable regarding balance, gait velocity, and muscle strength. In any case, the poor methodological nature of the studies incorporated into these reviews demonstrations to restrain both these reviews and the developed proof. In this manner, leading a review that centers around falls and includes just randomized controlled studies to decide if physiotherapy is gainful for fall chance decrease in individuals with PD.

A systematic review is increasingly confined in the center and tries to answer specific research inquiries from the available literature. However, the scoping review is a procedure intended to deliberately recognize the expansiveness of writing in a region being researched [1]. The intention of this paper was to scope the physiotherapy practice/role to prevent falls in patients with PD.

METHODS

A scoping review was conducted including determining the research question, determining relevant studies, study selection, charting the data, and finally collating, summarizing, and reporting the findings. The main phase of searching included choosing papers based on title and abstract. When every one of the titles was chosen, duplicates were removed. Irrelevant studies were disregarded. If there was any vulnerability to the significance of a study, the entire paper was read. The search strategy was modified

to suit different databases. The following electronic databases were searched in May 2019: Medline, Amed, Cinahl, PubMed, PsychInfo, Cochrane Library, Physiotherapy Evidence Database (PEDro) and the search was expanded with following references lists from selected articles.

The design of the study (controlled randomized trial), participants (people with PD), type of the treatment (compare the effect of a physiotherapy intervention to any comparable including other physiotherapy intervention), type of outcomes (report the effect of physiotherapy on fall and/or at least one fall risk factor), language (written in English), and availability of the full text were important and needed to be considered to find the most relevant studies.

The researcher independently extracted data from the studies by using a standard data extraction form. An outline of all the included material was condensed in a table that maps the literature. The literature was organized and

presented concerning the author, location and year of publication; aim, method, outcome measures, and results.

Findings

A total of 173 papers were identified before 25 duplicates were discarded. Following the screening of the titles and abstracts, 66 studies remained. In total, a further 29 articles were excluded after screening of full text and inclusion criteria, leaving 37 papers eligible for inclusion. Two additional articles were identified by hand searching; therefore, in total 39 articles were included in this scoping review (Figure 1). Fifteen of the included papers reported the direct effects of physiotherapy interventions on fall and furthermore inspected the effects on other risk factors. Whereas, the rest of the studies did not examine the benefits of physiotherapy interventions on fall directly. Instead, they announced different variables related to fall, for example, balance, functional mobility and gait as endpoints.

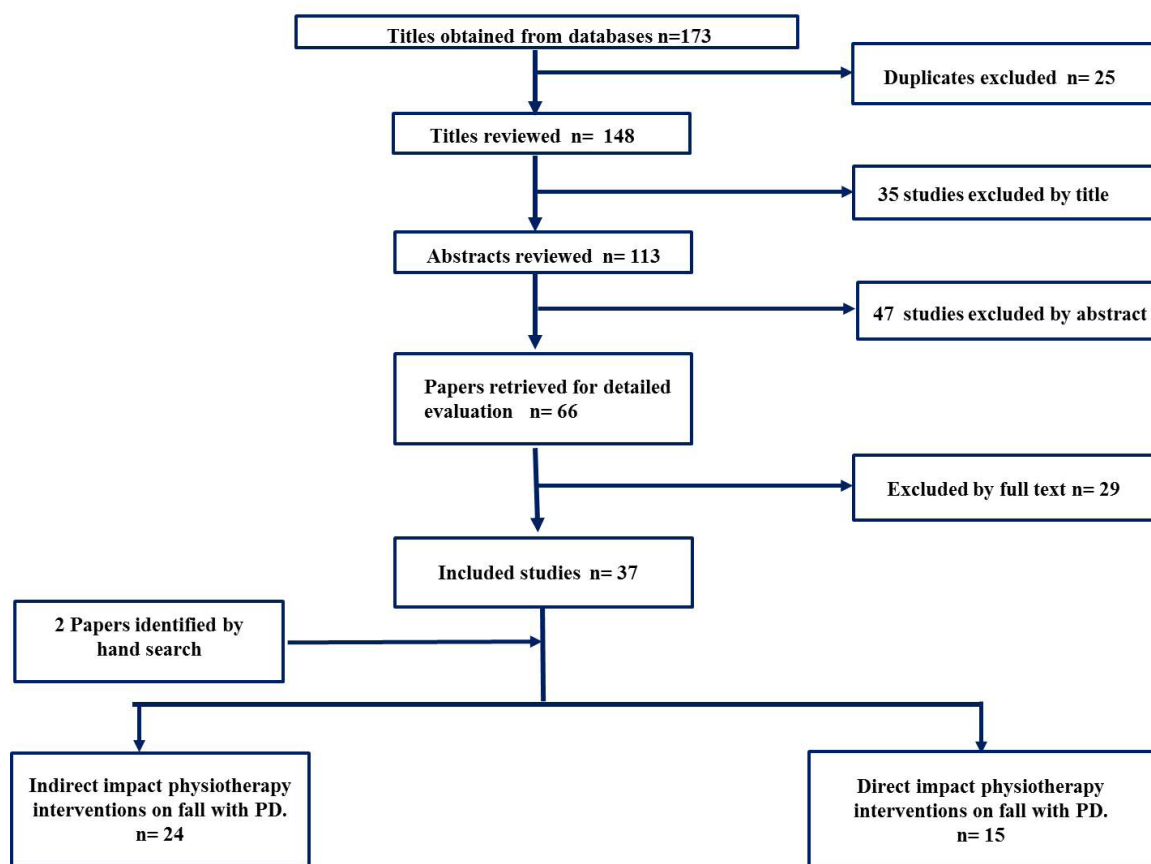


Figure 1: Flowchart showing the results of a scoping review.

Studies were reporting both fall incidence and fall risk factors.

The scoping search yielded 15 considers containing data important to the direct effect of physiotherapy intervention on fall rate and near fall incidence (Table I). Different physiotherapy interventions, duration, and outcomes were used in these studies.

Table 1: Studies of the direct impact of physiotherapy intervention on fall.

Author/Year/Location	Aim	Method	Outcome measures	Result/conclusion
Seymour et al (2019) The UK	To investigate the general potential benefits of fall prevention physiotherapy programme on people with PD	RCT 474 PD patients randomly allocated into : <u>Experimental group(n=238)</u> : People in this group were taught different home exercises aiming at fall avoidance and improving balance and strengthening exercise. <u>Control group (n=236)</u> : Participants in this group received DVD that might have involved instructions on falls rehabilitation therapy 12 supervised sessions of 1-1.5 hours for a duration of Six months.	<u>Primary outcome</u> : • Risk of repeat falling: (self-report diaries). <u>Secondary outcomes</u> : • Mini-BESTest: (balance). • Chair stand test. • FES1 • FOG. Different outcomes related to fall were assessed at three different points, i.e., before randomization, at the end of the study (6 months) and at 12 months after the study to follow up	1. The results of this study showed that there were significant improvements in terms of repeat falling (p=0.447) and near falling in favour of the intervention group 2. The exercise group had better balance (p=0.009), better fall confidence (p=0.026)and functional strength (p==0.041). Conclusion: Individual home exercise programme that was tailored to avoid fall with balance and strengthening exercise did not have the potential to reduce falling among people with PD.
Thaut et al., (2018) Canada	To determine whether or not rhythmic auditory stimulation(RAS) training is beneficial for fall reductions in people with PD	RCT 60 PD patients randomised into: <u>Experimental group(n=30)</u> : The subjects were asked to complete the RAS training exercises on a daily basis for 24 weeks. <u>Control group(n=30)</u> : Usual care	<u>Main outcome measures</u> : • BBS • TUG • Falls efficacy scale • The fall index. Outcome measures were collected at baseline, 8 th , 16 th and 24 th weeks.	1. <u>At week 8</u> : No significant improvement was noticed between groups. 2. <u>After 16 weeks</u> : The RAS group gained significant improvements in terms of fall index and FOF. 3. <u>At week 24</u> : There was a significant improvement in RAS training group in term of FOF and number of falls.. Conclusion: RAS training program was beneficial to reduce the number of falls in PD.
Sparrow et al (2016)	To investigate the benefits of physiotherapy exercise program intervention on fall rate, balance, and fear of falling in patient with PD.	RCT 23 subjects with PD were consequently placed into 3 months of active balance exercise or 3 months of inactivity (usual care) followed by the reserve. The program was held twice weekly /90 minutes/3 months.	<u>Main outcome measures</u> : • Falls • Balance: (Mini-BESTest). • Fear of falling: (FES-1). Assessment: baseline, 3 months, and at 6 months.	1. There was an evidence to support the effects of physiotherapy interventions on decreasing fall rate (37%) per month . 2. Significant improvements were noted in terms of Mini-BESTest (p=0.037) and FES-1 (p=0.059). Conclusion: Progressive exercise programs could demonstrate significant improvement in reducing the number of falls, improving balance and FOF with mild to moderate PD.
Wong-Yu and Mak (2015) China	To examine the short/long term effects of balance training on functional performance and number of falls in PD nonfallers.	RCT 70 PD randomly allocated into: <u>Experimental group (n=32)</u> : received indoor and outdoor balance training over a period of Eight weeks, Four weeks for each. <u>Control group (n=38)</u> : Two hours upper limb training sessions/week for a period of eight weeks	<u>Primary outcome measures</u> : • Balance (Mini-BESTest). <u>Secondary outcome measures</u> : • Functional research (FR) distance. • 5 times sit-to-stand (FTSTS) time. • TUG time Assessment: baseline line, 8 weeks, and 6 months.	Fall at follow up: 1- No significant improvement between groups was noticed in terms of total fall rates or numbers of fallers. 2- A significant improvement in the number of injurious fallers was noticed(p<0.05). Short and long term effects: 1. The balance group demonstrated significant improvement in Mini-BESTest (p<0.001), FR distance (p<0.05), FTSTS times (p<0.01) and TUG time (p<0.05) as compared to the baseline assessments. Conclusion: It seems that balance training program to be effective in term of dynamic balance and functional activities in people with PD nonfallers for up to 6 months after training.

PD: Parkinson's disease; RCT: Randomized controlled trial ; BESTest: Balance evaluation system test; FES-1: Falls efficacy scale-international score; FOG: Freezing of gait; BBS: Berg balance scale; TUG: Timed-up- and go; FOF: fear of falling

Table 1: Studies of direct impact of physiotherapy intervention on fall (Con).

Author/Year/Location	Aim	Method	Outcome measures	Result/conclusion
Shen and Mak (2015) China	To investigate the effects of technology-assisted balance and gait training on fall reduction in people with PD.	RCT 51 subjects were randomly assigned to either: <u>Experimental(BAL)group</u> (n=26):technology-assisted balance and gait training. <u>Control group</u> (n=25): strengthening exercise. Both groups receiving training for 12 weeks.	The primary outcomes: <ul style="list-style-type: none"> The number of falls. The fall rate. The time to first fall. The secondary outcomes: SLS. Postural response latency with Motor control test (MCT). Assessment were performed at baseline, 3-month intervention (Post _{3m}), at the 3-month follow-up month (Post _{6m}), and 12 month follow up (Pos _{15m}). The number of fall was recorded by subjects.	Primary outcome measurements: 1- There was a significant improvement in the number of falls in the intervention group at Post _{3m} , Post _{6m} , and at Pos _{15m} (P<0.05). 2- The intervention group had a significantly lower fall rates than the control group at Post _{3m} and Post _{6m} (P<0.05). Secondary outcome measurements: 1. The BAL group resulted in a significant reduction in the MCT and increase in the stride length when compared to the stretch group(P<0.05). 2. SLS time was increased in the BAL group throughout the follow-up period Post _{3m} (P=0.064), Post _{6m} (P=0.041) and at Pos _{15m} (P=0.087). Conclusion: Combining balance and gait training programs with technological devices is more beneficial than the strengthening training program only to reduce the number of fallers and fall rate over 15 months in people with PD.
Morris et al (2015) Australia	To examine the benefits of progressive resistance strength training (PRST) or movement strategy training (MST) on fall rate in people with PD over 12 months.	RCT 210 people with PD were allocated randomly into: Group1(PRST, n=70): Received progressive resistance strength training with education classes about falls prevention. . <u>Group 2</u> (MST, n=69): Received movement strategy training combined with fall prevention programmes <u>Group 3</u> (Control group, n=71): life skill information. 2 hour therapy/per week/for 8 weeks	Primary outcome: <ul style="list-style-type: none"> Falls rate. Secondary outcome measures. <ul style="list-style-type: none"> UPDRS TUG test VAS Outcome measures were collected at baseline, 8 th week, 3 months and 12 months after treatment. falls were taken using interviews with participants.	1. The results showed that 193 falls were recorded for PRST group, 441 falls for MST group and 913 falls for the control group over the period of 12 months. 2. The results showed that, compared to the control group, both PRST and MST groups had led to a significant improvements in terms of falls (P<0.001, P=0.012 respectively) For the 12-month follow-up test: 1. Both PRST and MST interventions resulted in significant positive impacts on UPDRS activities compared with control group (P<0.01 and P<0.01 respectively). Also, The MST group led to significant improvement in the UPDRS motor score compared with control group (P=0.017). 2. No difference between group for TUG from baseline to 12 month. Conclusion: Fall prevention programmes with strength training or movement strategy training has the potential to significantly reduce the rate of falls among people with mild to moderately PD
Martin et al., (2015) New Zealand	To examine the effects of cueing training program on falls in PD with FOG.	RCT 29 participants with PD were randomised into: <u>The first group</u> (n=12): received cueing training sessions for six home visits within the first 4 weeks over a period of 6 months, followed by weekly phone calls for the remaining 5 months. <u>The second group</u> (n=9): People in this group of the study were asked to wait 6 months and after the 6 months they immediately started their cueing training.	Main outcomes: <ul style="list-style-type: none"> NFOGQ. Number of fall: daily diary. The assessments were taken at 2 weeks after the end of study.	1. The results showed that the intervention had not led to significant differences in NFOGQ total scores (P=0.70), fall rate (P=0.008) and FOG(P=0.63) between groups after intervention Conclusion: Cued up intervention is acceptable and may improve falls and FOG in people with PD. however, further investigate is needed with large sample size.

PD: Parkinson's disease; RCT: Randomized controlled trial ; SLS: Single-leg-stance ; NFOGQ: New freezing of gait questionnaire; UPDRS: Unified Parkinson's disease rating scale ; TUG: Timed up and go; VAS: Visual analogue scale.

Table 1: Studies of direct impact of physiotherapy intervention on fall (Con).

Author/Year/ Location	Aim	Method	Outcome measures	Result/conclusion
Canning et al, (2015) Australia	To examine the effect of supervised exercise on fall and a number of fall risk factors, namely balance, muscle strength, and FOG in people with PD.	RCT 231 PD allocated randomly into: <u>Intervention group</u> (n=115): 6 month exercise program + falls prevention advice. <u>Control group</u> (n=116): Fall prevention advice only. Exercises were practiced 40-60 minutes/3times/week/ for 6 months.	Primary outcome measures: <ul style="list-style-type: none"> Number of falls. The proportion of fallers of participants during the study period. Secondary outcome: <ul style="list-style-type: none"> The PD fall risk score. Mean knee extensor muscle strength. The short physical performance battery (walking, standing balance, and sit to stand). 	1- The study failed to achieve a significant difference with regard to fall rates between both groups (P=0.18). 2- No significant difference was noted between the two groups in terms of the proportion of fallers(P=0.045). 3- A significant improvement was noticed in terms of functional task performance in the intervention group(P<0.05). Conclusion: Application of exercise program to target balance, leg strength and FOG did not reduce falls in people with PD.
Gao et al., (2014) China	To compare the effects of group-based tai chi exercise, and a control condition group on fall prevention in PD.	RCT 76 PD randomly allocated into: <u>Experimental group</u> (n=37): Tai Chi <u>Control group</u> (n=39): no intervention 36sessions/60 minutes each time/for 12 weeks.	Main outcomes: <ul style="list-style-type: none"> Motor function: UPDRS. Balance: BBS. Functional mobility: TUG. Outcomes were assessed at two different points, i.e., before randomization, at the end of the study(12 weeks). All participants were assessed at 6 months after the study to follow up to assess the fall.	At baseline: 1. There were no significant differences between the Tai Chi group and control group on all measures. At12 week: 1- A significant improvement in BBS score was noticed in the tai chi group(P<0.05). 2- No significant improvements in terms of UPDRS and TUG scores were noted in both groups (P>0.05). 3- Only the tai chi intervention resulted in a significant reduction in fall incidence at the 6-month follow up. Conclusion: The use of tai chi intervention to reduce fall incidence and fall risk can be useful in patients with PD.
Li et al., (2012) US	To compare the effects of Tai chi exercise with the effect of resistance-training or stretching exercise to improve postural control in Parkinson's disease.	RCT Participants (n=195) were randomly assigned to one of these three groups: <u>Tai Chi group</u> (n= 65): The tai chi intervention consisted of twice weekly classes for twenty-four weeks, with each class lasting for an hour. <u>Resistant training group</u> (n=65): strengthening exercises targeting those muscles responsible for improving balance, gait and posture. <u>Control group</u> (n=65): Stretching group	Primary outcomes: <ul style="list-style-type: none"> Postural stability: Two indicators of postural stability (maximum excursion and directional control). Secondary outcomes: <ul style="list-style-type: none"> Gait: (stride length and walking velocity). Muscle strength. Static balance. TUG. Outcome measures were repeated at 3 different times: at baseline, at 3 and 6 months	1- The results revealed that significant improvements in terms of gait velocity, gait parameters, muscle strength, balance and functional mobility measures were noted in both the tai chi and the resistance groups as compared to the stretch group. 2- Only the tai chi intervention resulted in a significant reduction in fall rates when compared to the stretch group. 3- The performance of the people in tai chi significantly outweighed the performance of those in the resistance group in terms of stride length and balance. 4- The improvements in the tai chi group remained at the same level even at three months after the end of the intervention. Conclusion: Tai chi training appears to reduce balance impairments, improve functional capacity and reduced falls in patients with mild to moderate PD.
Goodwin et al., (2011) UK	To compare the effects of ten sessions of group-based intervention, including strength and balance exercise with regular care, on fall rates and fall risks in people with PD	RCT 130 participants were randomly allocated into <u>Intervention group</u> (n= 64): Received a group exercise programme that commenced in five different community settings with twice-weekly home exercise programme. <u>Control group</u> (n=66): usual care. One hour/week/for 10 weeks.	Primary outcome: <ul style="list-style-type: none"> The number of falls/fall rates. Secondary outcomes: <ul style="list-style-type: none"> FESI; EuroQOL-5D Phone-FITT BBS TUG Assessments were completed at baseline, post intervention, and follow up (10 weeks)	1. No significant difference in falls between groups. 2. Significant difference was observed in BBS and FESI at the 10 week follow-up. 3. There were significant improvements in terms of balance, functional mobility and FOF in favour of the intervention group. Conclusion: The study did not demonstrate a statistically significant between group differences in fall.

PD: Parkinson's disease; RCT: Randomized controlled trial; FESI: Falls efficacy scale-international questionnaire; BBS: Berg balance scale; TUG: Timed up and go ; UPDRS: Unified Parkinson's disease rating scale; QOL-5D: Quality of life; FOF: fear of falling..

Table 1: Studies of direct impact of physiotherapy intervention on fall (Con).

Author/Year/ Location	Aim	Method	Outcome measures	Result/conclusion
Smania et al., (2010) Italy	To determine whether balance training can improve postural instability (PI), functional mobility, decrease FOF and reduce fall rates among people with PD or not.	RCT Sixty-four participants with PD were consequently randomly allocated to either: <u>Experimental group</u> (n=33) received balance exercises designed to improve both feedforward and feedback postural reactions. <u>Control group</u> (n=31) received active range of motion, muscle stretching and joint mobilization exercises, which did not target PI. Both control and treatment groups received a total of twenty-one sessions, three times a week and each session lasted for fifty minutes.	Primary outcomes: <ul style="list-style-type: none"> BBS ABC Postural transfer test. number of falls Secondary outcomes: <ul style="list-style-type: none"> UPDRS H&Y Staging Scale GDS. Each patients were evaluated before and after treatment/1 month	<ol style="list-style-type: none"> There were significant changes in the primary outcomes in the experimental group in terms fall reduction, FOF, balance, and functional mobility.. There were significant changes in the secondary outcomes (UPDRS and GDS) in the experimental group. Conclusion: Balance training targeting postural reactions has the potential to significantly improve postural instability.
Ashburn et al., (2007) UK	To determine whether or not a six-week home intervention was beneficial for people suffering from PD who also had a history of recurrent falls	RCT 142 PD randomly allocation into: <u>Intervention group</u> (n= 70): different exercise to improve balance, ROM and walking+ Initiating movement and fall avoidance + complete the exercise on a daily basis. <u>Control group</u> (n=72): Usual care in the hospital.	Outcome measures: <ul style="list-style-type: none"> Fall diary sheet(fall and near fall incidents). UPDRS. The Functional Reach test, BBS TUG SAS The Euro Quol. Measurements were applied at three different points: baseline, 8 weeks and at 6 months.	<ol style="list-style-type: none"> Home-based exercises over six weeks had led to a trend towards both lower fall rates and serious injuries associated with falls at two (P=0.004) and six months (P=0.007) in favour of the intervention group. A significant improvement in static balance was noticed at two and six months. No significant differences on functional mobility, muscle strength, or dynamic balance. Conclusion: Home exercise interventions may have a positive effect for people suffering from PD on near falls and quality of life.
Nieuwboer et al., (2007) Belgium	To examine the effects of movement strategies training in people with PD.	RCT 153 Parkinson patients randomly place into: First group (n=76): cueing programme treatment 9 sessions/30min/3weeks followed by a rest for three weeks. Second group(n=77): Wait three weeks and after the three weeks they immediately started their cueing training.	Primary outcomes: <ul style="list-style-type: none"> PIGD. Secondary items: <ul style="list-style-type: none"> Gait and balance measures. Activity measures Participation measures Three evaluations were conducted at three, six and twelve weeks respectively.	<ol style="list-style-type: none"> No significant improvement was noticed in terms of functional task performance. The intervention resulted in significant positive impacts on PG scores, gait velocity and FOF. (p=0.005). Effect of interventions had reduced considerably at 6-week follow-up. Conclusion: Cueing training may play an important role to the overall management of gait disturbance in PD.
Protas J. et al.,(2005)	To determine whether or not an eight-week intervention of gait and step training on a treadmill could improve gait and balance and decrease fall rates in people with PD.	RCT Eighteen (n=18) subjects were randomly assigned to either Experimental group (n=5): treadmill training 3items/ week/for 8weeks. Control group (n=6): Usual care .	Outcome measures: <ul style="list-style-type: none"> Gait parameters. 5-step test. Report of falls. Assessment were occurred before and after the end of study.	<ol style="list-style-type: none"> Gait speed was the only significant difference between the groups (in the trained group increased from 1.28±0.33 meters/sec to 1.45±0.37 meters/sec). The intervention group demonstrated significant improvement in gait parameters and fall rate as compared to baseline assessments which was not the case in the control group. Conclusion: Gait and step perturbation training might detect significant difference in terms of balance fall rate or other gait parameters

PD: Parkinson's disease; RCT: Randomized controlled trial; PIGD: Postural instability and gait difficulty; BBS: Berg balance scale; TUG: Timed up and go ; ABC: Activities specific balance confidence scale ;

UPDRS: Unified Parkinson's disease rating scale; H&Y: Modified Hoehn and Yahr; GDS: Geriatric depression scale; FOF: fear of falling; SAS: Self assessed disability scale; PG score: Posture and gait score

The sample sizes reported, with included studies, ranged from 18[14] to 474[6]. Eight studies[14-18] included 100 participants or less, and only four studies[22-25] had an initial sample size of between 130 and 195 participants. Therefore, the rest three studies[6;26;27] had an initial sample size of between 210 and 474 participants. Every included study in this part recorded the number of falls/near fall incidence or fear of falling. These studies recorded falls utilizing falls diary sheet, which is the best gold standard in view of participants/family[6;15-17;19;21;23-25], telephone interviews[14,19,21,22,27], or medical record observation[26].

Falls were reported at set of intervals, ranging one month[21], 8 weeks[14], 10 weeks[22]; three months[25], six month[15,17;19;23;24;26] or over 12 month period intervals[4;6;27].

These papers also include a variety of interventions related to the field of physiotherapy, including traditional physiotherapy exercises, movement and strategies training. In this way, this paper may give a far-reaching outline of the advantages of physiotherapy as far as fall risk decreases in individuals with PD. For example, the effect of exercise training[6;14;22;24;27] and balance training exercise[16;26;27] for fall prevention in PD have been tested in some studies.

The results of the included studies reported that no benefits of exercise training for fall preventions[6;14;22;24;26]. However, some studies reported significant reduction in falls when exercise containing strength and/or balance exercises [16;18;21;27]. Additionally, two randomized trials[20;23] analyzed the impacts of tai chi exercise on fall decrease in individuals with PD. The discoveries demonstrated that Tai Chi exercise had positive effects on reduc-

ing future falls.

The effectiveness of rhythmic auditory stimulation (RAS) has been resulted in decreasing the number of falls in PD disease[15,19,25]. Two RCTs reported that RAS concluded that RAS training significantly reduced the number of falls in PD[15,25]. Whereas, one RCT study[19] reported that RAS did not have important changes in falls in people with PD.

Furthermore, the interventions of the above studies led to significant improvement in terms of balance[6;15-17;20;22-25] functional mobility[6;15;17;18;22;23;26], Fear of falling (FOF) [16,21,22,26], fall rates[14,17-19,24,27], serious injuries associated with falls[17,24], freezing of gait (FOG) [6,19,25] and gait parameters[14,15,17,18,23,25]. Nonetheless, the resulting measures in most of these studies were assessed following the treatment.

Just a couple of studies had followed up evaluations. However, these studies had short followed up periods. In this way, it is difficult to give an end with respect to the long-haul impacts of physiotherapy on fall risk reduction. Only three studies had a one year follow up period, and the results showed that strength movement strategy training and multi-dimensional balance training, could reduce the rate of falls in people with mild to moderate PD[6,18,27].

Interventions that reported fall risk factors only.

Rather than the studies evaluated in the segment above, there are various studies that neither target fallers nor report fall numbers or close fall rate as results (Table 2). However, these studies examined the impacts of physiotherapy interventions on several factors that are closely associated with falls in people with PD, such as balance, functional task, gait, and muscle strength.

Table 2: Studies of indirect effects of physiotherapy on fall.

Author /Year/ location	Aim	Method	Outcome measures	Result
Sliva-Batista et al. (2018) Brazil	To examine the effect of resistance training with instability (RTI) and resistance training (RT) on balance and FOF in patients with PD.	RCT 39 subjects with PD randomly allocated into: <u>Experimental group</u> (n=26): <u>Exercise training</u> (RT n=13; RTI n=13). <u>Control group</u> (n=13): received no exercise training.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> Balance: (BESTest) Fear of falling: FES-1 score. Tests were repeated at two different points: at baseline and after three months (12 weeks).	1- A significant improvement in balance and FOF was noticed in the experimental group. However, this improvement was more effective in RTI than RT (P<0.05). Conclusion: Authors concluded that RTI has the potential to significantly improve balance and FOF among people with PD.
Conradsson et al., (2015) Sweden	To examine the effects of a ten week of balance program in people with PD.	RCT Participant with PD (n=100) were randomised into <u>Experimental group</u> (n=51) HiBalance program. <u>Control group</u> (n=49): Usual care The balance group training was performed: 3 times/week/60 minutes per session/ 10 weeks.	<u>The main outcomes:</u> <ul style="list-style-type: none"> Balance: Mini-BESTest. Gait velocity: during normal and dual-task (DT) gait. Falling: FES-1. Different outcomes related to fall and fall risk factors were assessed at two different points, i.e., before randomization and at the end of the study.	1- The results showed that there was a significant improvement in terms of balance (P=0.001) in favour of the experimental group. 2- As compared to the control group, the experimental group gained significant improvements in terms of DT gait. However, no significant effect of training for concerns about falling. Conclusion: The HiBalance program has the potential to significantly improve balance and gait abilities in patients with PD. However, no benefit was found for concern about falling

Wong-Yu and Mak (2015) China	To investigate the direct effect of multi-dimensional blended indoor and outdoor (BIO) balance training intervention in balance in people with PD.	RCT 84 PD randomly allocated into: Experimental group (n=41): completed 4-week indoor and 4-week outdoor balance training. Control group (n=39): completed 8 weeks upper limb training.	<u>The primary outcome:</u> <ul style="list-style-type: none"> Balance: (BESTest). <u>The secondary outcome measures:</u> <ul style="list-style-type: none"> Gait speed. TUG. Assessments were occurred at baseline, post-training assessment, 6 month follow-up assessment and 12 month follow-up assessment.	<ol style="list-style-type: none"> Short term effect: There were significant improvements in terms of BESTest total score (p<0.001), gait speed (p<0.05), and TUG (p<0.01) from baseline in favour of the experimental group. Long term effect: the experimental group had significantly increases in the BESTest total score (p<0.001), gait speed (p<0.05) and TUG (p<0.05) than control group. Conclusion: multi-dimensional balance training programme has the potential to significantly improve balance and dual-task gait performance up to 12 months among people with PD.
Volpe et al., (2014) Italy	To compare the effects of hydrotherapy treatment on balance with regular care in people with PD.	RCT Experimental group (n=17): Hydrotherapy. Control group (n=17): land-based standard rehabilitation. 60minutes/5weeks/2 months.	<u>The main outcomes were:</u> <ul style="list-style-type: none"> UPDRS BBS Falls efficacy scale Falls diary. Assessment was occurred at baseline, and one week after rehabilitation.	<u>At 10 week after rehabilitation:</u> <ol style="list-style-type: none"> By the end of the rehabilitation protocol, the hydrotherapy group gained significant improvements in terms of BBS (P=0.005), falls efficacy scale (P=0.003), falls diary (P=0.001). Conclusion: Hydrotherapy treatment was beneficial to address balance, postural stability and reducing falls rate in people with moderate stage of PD.
Duncan and Earhart (2012) USA	To explore the effect of a twice weekly tango programme conducted over a period of one year for individuals with PD.	Sixty-two patients with PD divided: <u>Intervention group</u> (n=26): Community based Argentine Tango program (2 sessions/60 minutes/week/ for 12 months). <u>Control group</u> (n=26): No intervention	<u>Primary outcome:</u> <ul style="list-style-type: none"> MDS-UPDRS-3. <u>Secondary outcome:</u> <ul style="list-style-type: none"> MDS-UPDRS-1. MDS-UPDRS-2. MiniBESTest balance test. FOG questionnaire 6MWT. Gait velocity. 9HPT. Outcome measures were applied before the study (at baseline), 3, 6, and 12 months.	<ol style="list-style-type: none"> After one year, the results revealed that the intervention group gained significant improvements in all outcome measures, as compared to baseline and to the control group (P=0.001). Conclusion: These positive results provide strong evidence for the efficacy of long term participation in tango in patients with PD.

PD: Parkinson's disease ; RCT: Randomized controlled trial; BBS: Berg balance scale; UPDRS: Unified Parkinson's disease rating scale; TUG: Timed up and go; BESTest: balance evaluation systems test ; FES-1: Falls efficacy scale-international; FOG: Freezing of gait; 6MWT: Six minute walk; 9HPT: Nine Hole Peg Test; MDS-UPDRS3: Movement disorders society-unified Parkinson's disease rating scale 3; MDS-UPDRS2: Movement disorders society-unified Parkinson's disease rating scale 2; MDS-UPDRS1: Movement disorders society-unified Parkinson's disease rating scale 1

Table 2: Studies reported the indirect effects of physiotherapy on fall(cont.).

Author /Year/location	Aim	Method	Outcome measures	Result
Stack et al. (2012) UK	To explore the effects of four weeks of a home-based physiotherapy program consisting of exercises and movement training strategies on two fall risk factors, namely balance and functional mobility.	RCT A total of 47 participants with PD divided into <u>The experimental group</u> (n=24): home physiotherapy programme focused on chair transfers (1 hour/ 3 times/week, 4 weeks). <u>Control group</u> (n=23): Usual care.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> Video-recorded (PAS; STS, SS-180, FR, Unified PD Rating Scale Posture Item. Questionnaires: (SAS; HR-QOL). The outcomes were taken at baseline, before intervention (week 0), after intervention (week 4) and at follow up (week 8 and 12).	<ol style="list-style-type: none"> The results showed that both groups had been comparable before the study. However, at the end of the treatment period, the programme group showed a tendency for improvement in all outcomes and the improvements were maintained throughout the evaluation period. In contrast, the control group showed a tendency for deterioration and this deterioration was increased throughout the follow-up period. Follow up: <ol style="list-style-type: none"> Median PAS score reaching 7 by week 12. STS times continued shortening to week 12 Median SAS score tended to worsen in both groups by week 12. Median SS-180 improved in the intervention group (3.8s). FR continued to improve in the intervention group (33% increase from baseline) while the control worsened. The median HR-QOL score of intervention group had returned to baseline while that of the control group was two points worse. Conclusion: a home-based physiotherapy programme consisting of exercises and movement training strategies may have a positive change in balance and functional mobility for people with PD.

Yi Yen et al (2011) Taiwan	To compare the effects of six weeks of traditional balance exercises, virtual reality-augmented balance training, and non-exercise control group on postural stability in individuals with PD.	RCT 42 PD patients were consequently randomized into three groups: Group 1 (n=14) : The virtual reality balance group (VR) trained on a virtual reality balance system for half an hour twice a week over six weeks Group 2 (n=14): The conventional balance group (CB) received a thirty minute-session twice a week for six weeks of balance exercises. Control group (n=14): did not have any type of exercise.	<u>Main outcome measures:</u> The equilibrium scores at the 6 condition of the SOT (SOT-1 to SOR-6).	1- A significant improvement was noticed in terms of SOT-6 score in VR group as compared to the control group (P=0.001). 2- In terms of the equilibrium score of SOT-5, a significant improvement was noticed in CB group as compared to the control group(P=0.001). Conclusion: Both virtual reality and traditional balance exercise were beneficial to address balance, since both groups showed significant improvement as compared to the control group.
Chaiwanichsiri, D. et al., (2011) Thailand	Evaluate the effectiveness of music cue on treadmill training with idiopathic Parkinson's disease .	RCT 30 participants divided into three groups: <u>Group A</u> (n=10): Tried mail training with music cue and walking. 3d/w. <u>Group B</u> (n=10): Tried mail training with walking.3d/w. <u>Group C</u> (n=10): walking only.6d/w.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> Fall(s) within the past six months. Gait and balance performance: (TUG, ETUG, SLST, 6-MWT). Step length and stride length. Walking speed Cadence. The outcome measures were assessed three times at the beginning of study, after four week of training program and after the end of eighth week.	1- The results showed that stride length(P=0.042), step length(P=0.037) and the six-minute walking test time (P=0.001) improved more in the treadmill with cueing group, than in any other. 2- TUG test improved in group A and B more than C at 4 th week (P=0.039). Conclusion: Application of music cueing may increase the benefit of the treadmill training in PD patients. .

PD: Parkinson's disease; RCT: Randomized controlled trial; CB: Conventional balance training; PAS: Parkinson's activity scale; SS-180: Standing start 180 degree test; FR: Functional research; SAS: Self assessed disability scale; SOT(SOT-1 to SOR-6): Sensory organization test' HR-QOL: Quality of life; STS: Sit-to-stand; VR: Virtual-reality; SLST: Single-leg-stance test; TUG: Timed up and go; ETUG: Expanded timed Up and Go test.

Table 2: Studies reported indirect effects of physiotherapy on fall(cont.).

Author /Year/ location	Aim	Method	Outcome measures	Result
Reuter,I.et al.,(2011) Germany	To examine the effects of two different over-ground walking programmes and traditional physiotherapy exercises.	RCT 90 PD patients were allocated into three groups and each group practised different interventions: Group1: Nordic walking (NW) training. (attend three 70 minute sessions per week of Nordic walking for six months) 3times/w/6months. Group2: walking training 3times/w/6months. Group3: flexibility exercises and a relaxation training Three 70minute sessions per week for six months.	<u>Primary outcome:</u> <ul style="list-style-type: none"> Gait speed and gait parameters as assessed using a treadmill ergometer and 12 metre and 24 metre walking tests. UPDRS, PDQ39. <u>Secondary outcome:</u> <ul style="list-style-type: none"> The secondary outcomes were static and dynamic balance, as measured by the Berg Balance Test and the balance Pull Test respectively. Outcome measures were utilized before and at the end of the programme.	1. The results of the study showed that, compared to the baseline assessment, all groups gained significant improvements in terms of balance. However, only the walking and Nordic walking groups gained significant improvements in terms of gait velocity, stride length and double stance as compared to the baseline. These improvements were also significant when compared to the traditional physiotherapy group. 2. The results revealed that the Nordic walking group improved more than the walking group in all outcomes. Conclusion: the authors concluded that all programmes are beneficial to improve balance. However, only the walking programmes are beneficial to improve gait velocity and gait patterns.

Ebersbach et al., (2010) Germany	To compare the effects of four weeks of a one-to-one high-amplitude movement programme (LSVT BIG), Nordic walking programme, and unassisted home exercises	RCT Sixty patients with PD were randomly divided across these groups: Group 1: one-to-one training (LSVT BIG), (4 sessions/week/over 4 weeks) Group 2: training of Nordic Walking (WALK), (2 sessions/week/ for 8 weeks) Group 3: domestic non-supervised exercises (HOME) (1 session/ 60 minutes).	<u>Primary outcome:</u> • UPDRS. <u>Secondary outcomes:</u> • PDQ-39. • TUG. • Time to walk 10 m. Outcome measures were applied both before the study and at week sixteen (follow up).	1. The results indicated that all groups showed statistically significant improvements in all outcome measures as compared to the baseline. However, people in the LSVT BIG improved better than those in the Nordic walking or home group in terms of UPDRS-motor scale (P=0.001), TUG (P=0.033) and 10 m walking. 2. There were no significant group differences for PDQ39 Conclusion: The study showed that LSVT1BIG is an effective technique to improve motor performance in patients with PD.
Allen et al (2010) Australia	To examine the effects on near fall incidence and fall risk factors of a semi-supervised exercise programme containing a cueing component in people with PD. .	RCT 48 participants with Parkinson's disease (PD) were randomised into : Intervention group (n=24): progressive balance and strengthening exercise Control group(n=24): usual care. (3times/ week/6months).	<u>Primary outcome measure:</u> • PD falls risk score. <u>Secondary outcome measures:</u> • BBS. • FOG questionnaire. • Physical ability: the short physical performance battery (SPPB) (balance standing; sit to stand time; walking velocity). • FES-I questionnaire. PDQ-39.	1- The results showed that the intervention group demonstrated a better improvement in all outcomes. 2- The only significant between-group differences were noted in terms of near fall incidence, FOG(P=0.03) and the sit-to-stand task(P=0.03). Conclusion: Exercise program for PD who had a history of recurrent falls or who had been classified as being at high risk of falls may reduce overall risk of falling and can improve FOG, sit-to-stand, and muscle strength.
Sage and Almeida (2009) Canada	To compare the effects of movement strategies training (PD SAFEx), aerobic programmes and a control group.	RCT 53 participants with PD randomly allocated into: <u>Intervention group</u> (n=18) : PD SAFEx training programme. This programme was delivered via a group-sitting approach, three times a week, over a ten to twelve week period <u>Aerobic group</u> (n=13): lower limb aerobic programme.. Thirty-six classes over a period of twelve weeks <u>Control group</u> (n=15): non-exercising.	<u>Main outcome measures:</u> • UPDRS • PG score. • TUG. • Spatiotemporal aspects of self-paced gait. Outcomes were evaluated before(pre-test) and at the end of the study(post-test)..	1- Motor function: There was a significant improvement in PD SAFEx group (P< 0.001). 2- Both movement strategies training PD SAFEx (P<0.06) and aerobic(P<0.096) groups had improved in their performance on TUG, step length, double support time, PG score and gait velocity . However, none of these improvements were significant when compared to the control group. Conclusion: Authors concluded that functional movement control could be altered by SAFEx training programme in people with mild to moderate PD.

PD: Parkinson's disease; RCT: Randomized controlled trial; UPDRS: Unified Parkinson's disease rating scale; TUG: Timed up and go; FOG: Freezing of gait questionnaire; NW: Nordic walking; PDQ-39: Parkinson's disease questionnaire; PG score: Posture and gait score .

Table 2: Studies reported indirect effects of physiotherapy on fall(cont.).

Author /Year/location	Aim	Method	Outcome measures	Result
Hackney and Earhart (2009) USA	To compare the benefits of thirteen weeks of tango and (waltz/foxtrot) interventions and no physiotherapy treatment on functional motor control in people with PD.	58 people with PD were subsequently randomly allocated into the three groups Group1 (n= 14) tango, Group 2 (n=17) waltz/foxtrot or Group3 (n=17) no intervention " control group ". People in the tango and waltz/foxtrot groups attended twenty classes over thirteen weeks, while people in the control group received only pre- and post-study assessments.	<u>Main outcome measures:</u> • UPDRS. • BBS. • TUG. • 6MWT. • FOG questionnaire. All assessment measures were videotaped a week before and after the study.	After completion of 20 training sessions: 1- The results revealed that although all groups had been comparable at the pre-study tests, both tango and waltz/foxtrot groups had improved more than the control group in all outcomes. 2- Compared to the control group, both tango and waltz/foxtrot groups had significant improvements in balance, gait endurance and backward stride length. 3- With regard to FOG and the TUG tests, only the tango group had improved statistically. Conclusion: Tango and waltz/foxtrot may benefit in fall risk factors in PD.

Frazzitta et al., (2009) Italy	To compare the effects of treadmill training in association with visual and auditory cues and traditional over-ground gait training programmes.	RCT 40 Parkinson's patients were randomly and equally divided into: Group1 (n= 20) : Twenty minutes of treadmill training associated with auditory and visual cues over four weeks on a daily basis Group2 (n=20) : Over-ground gait training for the same duration using only auditory and visual cues.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> • UDRS. • FOGQ • 6MWT. • Gait speed • Gait stride. All measurements were assessed both before (baseline) and at the end of study (post-treatment).	Post-treatment: Both groups had gained significant improvements in all areas. However, the gains achieved after the treadmill training appeared to be superior to those achieved after the over-ground training(all P=0.001). Conclusion: treadmill training associated with visual and auditory cues could be more effective than traditional rehabilitation with auditory and visual cues alone.
Fisher et al (2008) USA	To compare the effects of gait training on a partial weight support treadmill system and a conventional physiotherapy programme consisting of a wide range of exercises for people with PD	RCT 30 PD patients were recruited and randomized to three groups: Group 1:(treadmill intervention): High intensity exercise.(twenty-four sessions of partial weight support treadmill training over a period of two months). Group 2(conventional exercises): Low intensity exercise.(twenty-four sessions of low intensity exercises over a period of two months) Group 3: Zero-intensity (no exercise) group. 24 sessions over a period of two months.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> • UPDRS. • Walking test. 10m. • STS test. • CSP. The effects of the programmes were assessed at two different points, both before randomization and immediately after the end of the study	1- The results showed that all groups gained slight improvements. However, there were no significant pre-post programme changes in all outcome measures across any of the groups. 2- Some improvements have been recorded in the high intensity exercise regarding self-selected gait speed (4.4%), stride length (4.7%), step length (5.8%), hip and ankle and lengthening in CSP. Conclusion: Intensive wide range of exercises may play an important role in corticomotor excitability in early PD.
Morris et al., (2008) Australia	To compare movement rehabilitation strategies training and conventional physiotherapy programmes in hospitalized patients with PD.	RCT 28 PD patients were equally assigned to either Group 1(n=14): movement strategy training. Group 2(n=14): Musculoskeletal exercises.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> • Disability (UPDRS). <u>Secondary outcomes:</u> <ul style="list-style-type: none"> • Balance, walking speed, endurance and quality of life (PDQ-39). Assessments were conducted three times, at baseline before the study, at the end of the two weeks and finally three months after the end of the study.	<ul style="list-style-type: none"> • The movement strategies group had gained significant improvements in all outcome measures including UPDRS scores (P=0.008), balance (P=0.002), 10 meter walk (P=0.003) and PDQ39. However, these improvements had declined by the three month follow-up. • The conventional exercise group, did not show any significant improvement. • The results indicated that two weeks of cognitive motor training led to short-term benefits in terms of static balance, walking velocity, walking endurance and disability level. Conclusion: Movement strategy training led to short-term benefits in terms of static balance, walking velocity, walking endurance and disability level

PD: Parkinson's disease; RCT: Randomized controlled trial; TUG: Timed up and go; BBS: Berg balance scale; FOG: Freezing of gait; UPDRS: Unified Parkinson's disease rating scale; CSP: Cortical silent period questionnaire; 6MWT: 6-Minute walk test; PDQ-39: Parkinson's disease questionnaire; STS: sit-to-stand; FOGQ: Freezing of gait questionnaire.

Table 2: Studies reported indirect effects of physiotherapy on fall(cont.).

Author /Year/ location	Aim	Method	Outcome measures	Result
Kurtais.et al.,(2008) Turkey	To investigate the effects of gait training on the treadmill on different functional tasks, gait velocity and static balance in patients PD.	RCT 30 patients with PD were consequently divided into either: <u>Intervention group</u> (n=12): Treadmill training. (3times/w/6weeks). <u>Control group</u> (n=12): No intervention.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> • Functional tasks. • balance Assessments of patients were carried out at baseline and at the end of treatment.	Results showed that people in the treadmill group gained significant improvement in in functional lower extremity tests as compared to the control group. Conclusion: Treadmill training in PD patients may improve functional mobility and static balance.

Mak and Hui-Chan (2008). China	To examine the effects of a movement strategies training programme and traditional physiotherapy intervention on an important functional task, sit-to-stand.	RCT. 60 PD patients were randomly allocated into: Group1 (n=21): receive AV cued task-specific training (twenty minutes, three times a week / for 4 weeks). Group2 (n=21): conventional exercise (Ex), (45 min/ 2 weeks/ for 4 weeks). Control group (n=18): did not receive any treatment (4 weeks).	<u>Main outcome measures:</u> • Three dimensional kinematics data of STS were recorded using a VICON motion analysis system with 6 cameras. Measurements were carried out before(week0), during (week2), at the end of the study(week4) and two weeks after the study	1- The AV group significantly increased with the Ex. Group. 2- Only the cueing and exercise groups gained significant improvements in terms of sit-to-stand time as compared to the baseline (P=0.01). These improvements were also statistically significant when compared with the control group. The improvements were also maintained at two weeks after the end of the study. Conclusion: AV cued task-specific training may play an important role in improving functional performance in patients with PD.
Hackney et al. (2007) USA	To compare the effects of thirteen weeks of two movement programs: Argentine tango dance lessons (tango) or a strength/flexibility exercise classes (exercise) on gait, functional mobility and balance.	RCT 19 PD patients were allocated randomly to either: Group1(n=9): Tango. Group2(n=10): Exercise. 1 hour /week/20 sessions/ for 13 weeks	<u>Main outcome measures:</u> • UPDRS. • BBS. • Gait velocity: 5-m walking. • TUG. • FOG questionnaire The performance on these scales was recorded on a videotape both before and after the intervention.	1- The results showed that the people in the tai chi group improved better than the control group in the UPDRS (P=0.001); BBS (P=0.001); , backward walking velocity, gait stride and also in terms of gait endurance. Conclusion: Tai chi leads to positive benefits in terms of gait, balance and functional mobility specific to PD.
Cakit et al., (2007) Turkey	Examined the effects eight weeks of gait training on the treadmill on postural instability, balance and FOF with PD patient.	RCT 54 with PD were equally separated into: <u>Experimental (treadmill training)group (n=27):</u> received speed dependent treadmill training, combined with range of motion and stretching exercises. <u>Control group (n=27):</u> did not receive any training	<u>Main outcome measures:</u> • Functional status: UPDRS. • Balance: BBS. • Dynamic gait index. • Falls efficacy scale. The participants have been evaluated before and at the end of the study.	The result showed statistical significance for the outcomes between the groups at baseline and eight weeks. The intervention group had significant changes in walking distance (from 2.66.45m to 726.36m) and tolerated maximum speed on treadmill(1.9km/h to 2.61km/h), Berg balance test, Dynamic Gait Index (P=0.01)and Falls Efficacy Scale. Conclusion: Treadmill programme had led to significant improvement on mobility and FOF in patients with PD.
Schmitz-Hubsch et al (2006) Germany	To evaluate the immediate and sustained effects of Qigong on motor and non-motor symptoms of PD.	56 patients with PD distributed randomly into: <u>Intervention group (n=32):</u> Two courses of Qigong exercise (60minutes/8weeks with 8 week pause in between). <u>Control group (n=24):</u> Usual care	<u>Main outcome measures:</u> • UPDRS-III. • PDQ-39. • Quality of life. • MADRS. Measurements were repeated at four different points: at baseline, at three months, at six months and after one year.	1- The results showed that the improvement in balance (UPDRS-III) was only significant at six months (P=0.050) in favour of the Qigong group. 2- There was a significant difference in postural stability in favour of the Qigong group (P=0.004). 3- No significant differences were noted between the two groups in terms of PDQ-39. 4- Score in MADRS for depressive symptoms decreased in both groups. Conclusion: Qigong is a promising treatment with possible effects on motor as well as non-motor symptoms with PD.

PD: Parkinson's disease; RCT: Randomized controlled trial; UPDRS: Unified Parkinson's disease rating scale; PDQ-39: Parkinson's disease questionnaire ; AV audio-visual; STS: sit-to-stand; BBS: Berg Balance Scale; TUG: Timed Up and Go; FOG: Freezing of gait; UPDRS-III: The unified Parkinson's disease rating scale motor part; MADRS : The Montgomery –asperg depression rating scale.

Table 2: Studies reported indirect effects of physiotherapy on fall(cont.).

Author/Year/location	Aim	Method	Outcome measures	Result
Hirsch et al., (2003) USA	To compare the effects of ten weeks of a programme consisting of a combination of balance and resistance training with a control group who received balance training only on PD.	RCT A total of 15 participants with PD divided into: Group 1 (n=6) : received resistance training and balance training exercises (combined group). Group 2 (n=9) : received balance training only. People in the balance group received half an hour of balance exercises, three times a week for ten weeks, while the combined group received fifteen minutes progressive resistance exercise in addition to thirty minutes of balance exercises.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> Balance: SOT. Muscle strength. All measurements were obtained at baseline, post-treatment (with 5 days of completion of training) and follow up .	1- It appeared that the combination of balance and resistance exercise led to more benefits in terms of balance and muscle strength and these were statistically significant. 2- Four weeks after the training ended, the mean for the balance group declined to near pre-treatment level, whereas scores for the combined group declined moderately. Conclusion: Both interventions are beneficial but, combining balance with strengthening exercise is more beneficial may reduce fall risk for people with PD.
Pohl et al (2003) Germany	To explore the immediate effects of thirty minutes of different gait training techniques on gait parameters in patients with early PD.	RCT 17 PD patients were assigned randomly either: Group 1: Structured speed dependent treadmill (STT). Group 2: Limited progressive treadmill.(LTT). Group 3: Over-ground traditional gait training(CGT), and Control group.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> Walking velocity. stride length. 	1. The results showed that training on both treadmill interventions had led to significant improvements(P=0.01) compared to the pre-training tests and both control and over-ground gait training interventions. Conclusion: The authors concluded that gait disturbance in people with PD could be altered by only one session of treadmill training (STT) or LTT, but not through CGT and the control group.
Muller et al., (1997) Germany	To compare the effects of ten weeks of a programme that used different movement training strategies, targeting different functional tasks, with a control intervention on postural and gait initiation in Parkinson's disease.	RCT 29 patients with PD randomly distributed into: <u>Experimental group</u> (n=15): specific strategies(such as cueing, dividing complex tasks and aiming at improving different functional tasks.). <u>Control group</u> (n=14): non-specific treatment (information about disease and breathing exercise). Both groups received a session of an hour and a half every week.	<u>Main outcome measures:</u> <ul style="list-style-type: none"> UPDRS. Modified Hoehn and Yahr Scale. ADLs Beck depression Inventory.	1. The result showed that statistically significance between group differences were observed in beck depression inventory, mentation, behavior and mood. 2. The intervention group gained significant improvements in balance as compared to the control group. 3. The motor examination, activities of daily living, and Hoehn and Yahr Scale showed a significance improvement pre-post treatment only in the intervention group. forward bending during walking showed a significance decline in the control group. The time to onset of arm flexion demonstrate a significant in the intervention group compared with control group. Conclusion: Behavioral treatment in PD could improve motor disability in moderately advanced PD patients.

PD: Parkinson's disease; RCT: Randomized controlled trial; SOT: Sensory Organization Test; UPDRS: Unified Parkinson's Disease Rating Scale; STT: Structured speed dependent treadmill; LTT: Limited progressive treadmill; CGT: Over-ground traditional gait training

Effect of balance

The significance of balance in fall avoidance is featured. In this scoping review, a few studies detailed the impact of physiotherapy intervention on balance[28-44].

Fourteen studies out of the Seventeen papers that reported on balance showed physiotherapy intervention had led to statistically significant improvement in at least one of the balance measures either as compared to control or active interventions[28-34,36,37,39,40,42-44]. However, only three studies did not report significant effects[35,38,41]. One of the three studies that did not report a remarkable difference between- groups used exercise in the comparison intervention[38]. However, this study did report a sig-

nificant difference as compared to the baseline data within the same group. The second study[41] compared the effect of physiotherapy intervention to control and found a trend towards improvement in the intervention group, while the control group showed a tendency for deterioration. The third study, by Hackney et al., 2007[35], compared the effects of tango dance or strength/flexibility exercise. The study also reported that balance might be beneficial to address balance and gait problems specific to PD.

Effects of functional mobility/performance on functional tasks.

Various studies have analyzed the impact of physiotherapy on functional performance. In this paper, Seven studies

were reliable in giving the outcomes that physiotherapy intervention leads to a significant improvement in performance on functional task measures as timed up and test (TUG), sit-to-stand test, and climbing stairs[34,37,38, 41,45-47]. In light of the after-effects of these trials, it gives the idea that physiotherapy is advantageous as far as enhancing functional mobility. However, different physiotherapy programs and different durations were used in these studies. This makes it hard to propose the best kind of physiotherapy to address this issue.

A few authors have contended that notwithstanding the motor symptoms associated with PD sufferers are still typically ready to perform complex movements in specific circumstances[36].

Therefore, they suggest using movement strategies training to compensate for and bypass the deficits in the basal ganglia. Three studies used movement strategies training either as a stand-alone intervention or combined with other exercises, and each showed positive results[38,44,46]. However, other studies examined the effects of programs that did not include movement strategies and showed positive results[34,37]. These programs include tango or treadmill. Thus, it makes it difficult to pinpoint which type of physiotherapy is more effective.

Effect on gait/muscle strength

Fifteen studies included in this part of the scoping review reported outcomes related to gait deficits and showed promising results[29,34-40,42,46-51]. The most result measure used to assess gait quality in these studies is gait velocity over a short distance, Ten of which indicated significant enhancement on account of the physiotherapy[29,34,36-38,40,42,47,48,51]. Other gait results, for example, stride length and walking endurance, were additionally assessed in a few studies and were found to enhance with physiotherapy[34,36,48,49].

Other findings, emerging from the results of the reviewed studies, related to gait and fall risk is that people suffering from FOG are likely to benefit from physiotherapy. However, this finding rises out of a predetermined number of studies.

Just six trials provided details regarding gait freezing[34-36,40,44,48]. Three out of the six trials demonstrated positive results for physiotherapy either when contrasted with control or some other active intervention[40,44,48]. The lack of significant improvements in the other three studies does not necessarily indicate the absence of the benefits of physiotherapy. To illustrate, all of these studies did not target FOG specifically and did not include such a problem as an inclusion or exclusion criterion.

Effect of muscle strength.

It appears that muscle strength may likewise enhance after physiotherapy in individuals with PD⁴⁴. Hirsch et al., (2003) [31] compared the benefits of two physiotherapy interventions on two fall risk factors, namely balance and muscle strength. In this study, Hirsch et al. (2003) [31] compared the effects of ten weeks of a program consisting

of a combination of balance and resistance training with a control group who received balance training only. The results of this study were promising and showed that both groups gained significant improvements in all outcomes, and these gains were maintained for at least four weeks. However, the program of this study mainly focusing on muscle strength. Whereas strengthening training, in another study, represents a small portion of the programmes. For example, Allen et al. (2010) [44] used resistance training as a component of a program that included cueing strategies and balance training. Therefore, it might be argued that the dose of the strengthening exercise was not sufficient enough to produce change in muscle power.

DISCUSSION

The direct impact of physiotherapy interventions on fall

Even though falling is predominant among those experiencing PD, little work has been done to prevent this issue. Only 15 studies examined the direct effect of physiotherapy in the fall in this specific population. The sample size was small in most of the inspected studies. Besides, the subsequent periods in the included studies were moderately short, with most of the studies looking at the impacts of physiotherapy immediately after the end of the interventions.

However, despite these restrictions, this paper represents the accessible studies that inspect the advantages of physiotherapy for individuals with PD. The immediate effects of physiotherapy in fall were estimated in these studies in terms of fall number and near fall incidence. These results were gathered fundamentally utilizing a self-reported fall diary sheet that was finished by participants themselves or medical staff. However, although fall diaries are considered valid and a reliable way to record fall incidence, factors such as participants' ability to recall fall incidence, education level, and native language may affect the accuracy of the recording of fall in such diaries, and this should be considered when using this approach[52]. Despite this, the consequences of this scoping review propose that physiotherapy intervention may be powerful in decreasing the quantity of falls and near fall incidence in individuals experiencing PD[15-17,19,21,23,24,26]. This suggestion is based on limited evidence. Eleven studies showed that physiotherapy resulted in a reduction on fall rate[14,15,17,18,21-24,26,27]. Yet, this reduction was significant only in seven studies[6,15,18,21,23,26,27]. Also, one study reported near fall incidence as outcomes and showed significant reduction[24]. The absence of a significant decrease in fall numbers in this study does not demonstrate the absence of the impacts of physiotherapy. Rather, it may indicate the lack of adequate sample size to detect this change statistically, as noticed in the studies conducted by Protas et al., (2005) [14], Martin et al., (2015) [19]. Another conceivable explanation behind the absence of significant improvement in terms of fall rates is the absence of incorporating appropriate intensity and type of training. Observably, every one of the interventions that did not reveal remarkable improvement involved interventions of moderately brief length or

exercises that did not challenge balance, while the proof rising out of studies concerning the older population in general, recommend a higher dose of exercise and activities that challenge balance to achieve a positive impact on fall rate[7,44]. For example, Sherrington et al., (2008) [7] conducted a systematic review and meta-analysis and indicated that approximately half of fall incidence among older people could be prevented by a well-designed program with a dose of at least 50 hours over the trial period. Additionally, they brought up that intervention, including exercise, that challenges balance capacities are bound to counteract fall more often than those intervention comprising of different sorts of activities, for example, walking or strengthening exercises.

Therefore, it is not surprising when a significant reduction in fall number was noticed in the studies[20,21,23] that incorporated a tai chi exercise program with a high dose (1 hour, twice weekly for six months > 50 hours). The tai chi exercise is also considered balance-based exercise.

Similarly, Smania et al., (2010) [21] used a variety of exercises that significantly challenge balance in different situations including standing, walking, and when doing functional activities and a significant reduction in fall numbers was demonstrated. However, the dose of this program was one hour twice weekly for seven weeks, which was lower than the recommended dose (< 50 hours). Thus, it might be argued that interventions consisting of only balance exercises that exceptionally challenge postural control in various circumstances may be a decent system to prevent falls in individuals with PD, even with the portion lower than the suggested dimension. However, this needs further examination. Another related finding is that programs that, for the most part contain fortify preparing appear to be not viable in terms of fall rate decreasing in individuals with PD. Some included studies exploring the advantages of a strengthening exercise program and demonstrated that the strengthening activity had not caused any significant decrease in fall occurrence in correlation with the control group[23,27,19].

It is consistent with several systematic reviews concerning falls in general in older people. For example, Sherrington et al., (2008) [7] conducted a systematic review of 44 controlled randomized trials and showed that strengthening exercise alone is not beneficial for older people who suffer from recurrent falls. Another study has been conducted by Shen et al.(2016) [11] showed that no clear evidence that training exercise decreased the number of fallers in PD over the short- or long- term.

Besides, due to the limited number of trials reviewed in this paper which report the direct impact of physiotherapy on fall, these findings should be interpreted with caution. Furthermore, more control randomized trials with large sample sizes are required both to affirm these discoveries as well as to locate the intensity and type of exercise. Additionally, it should be clarified that all these trials included individuals with PD who did not have other neurological conditions and who were mentally and medically stable. In

this way, generalization of these findings to other populations is not advisable.

Indirect effects of physiotherapy on fall effect on a composite score:

Recruiting many people can prove challenging to achieve, primarily when researchers target a specific population such as people with PD[44]. For this situation, composite score is a decent technique to be used[44]. The composite score can be utilized to demonstrate the risk of falling, and the consequence of the reviewed trials show that physiotherapy may positively affect such a measure. In this paper, two studies used a composite score (PIGD) that includes items related to gait and balance[25,46]. These two studies exhibited that physiotherapy interventions lead to significant positive effects on such a score when contrasted with usual care.

Nonetheless, there is no one study that examined the sensitivity of this measure to foresee future falls. Then again, one study focused on fallers utilizing a composite score, PD fall risk score, that incorporates commitment that includes weight from muscle strength, balance, and FOG[44]. The authors in this study cited the validity and reliability of this measure. However, they found that physiotherapy did not result in any significant improvement in this score when compared to usual care.

Effect on Balance

Considering the consequences of the studies included in this paper it appears that different types of physiotherapy can enhance balance. These types include traditional balance training, virtual reality balance training, resistance exercise, tai chi, movement training strategies, treadmill training, and multi-dimensional interventions. In any case, because of the various number of measures utilized, and the limited number of studies that analyze the impacts of different physiotherapy intervention on balance, it is not clear what sort of physiotherapy is the most beneficial for balance. A systematic review conducted by Addison et al., (2009) [53] contends that the type of physical activity may lead to an improvement in balance performance. Although this discovery supports the use of physiotherapy, the degree of advantages is not known. Accordingly, future studies should address this impediment and focus on identifying the best intervention to target balance impairment in people with PD.

Effects on functional mobility/ performance on functional tasks

Difficulty in performing functional tasks is one of the problems associated with PD and is strongly associated with fall. Measures intended to assess functional performance can be utilized either to assess balance or fall risk in individuals with PD. Consequently, various studies[6,29,21-23,34,37,45] have analyzed the impact of physiotherapy on such results. In view of the results of these trials, it gives the idea that physiotherapy is advantageous regarding enhancing functional mobility. However, distinctive physiotherapy programs and diverse duration were

utilized in these studies. This makes it hard to propose the best kind of physiotherapy to address this issue.

Effects on gait

Abnormal gait is, with no uncertainty, one of the elements that are unequivocally connected with fall and balance in individuals with PD. In this paper, distinctive interventions related to gait deficits were utilized in the included studies and showed promising results. These interventions were various, going from movement strategies training to daily walking at home. Therefore, extracting a message about the best method to improve gait speed, stride, and endurance is difficult. Be that as it may, it creates the impression that interventions involving walking exercise or movement strategies training are more valuable than those without[36,51]. Additionally, the results of the reviewed studies suggest that treadmill training, nordic walking and amplitude movement training are better than traditional over-ground gait training[38,46,48]. However, these recommendations depend on a set number of studies and need further investigation.

Effects on muscles strength

Lower limb muscle strength is an important fall risk factor. It has been found that there is a strong relationship between lower extremities muscle strength and fall risk in people with PD[15]. This is normal because these muscles play a role in maintaining static and balance in people[44]. Moreover, there is a connection between muscle strength and gait patterns and walking ability which are also considered fall risk factors in people with PD[50]. Given the consequences of the studies incorporated into this paper, it appears that muscle strength may likewise enhance after physiotherapy in individuals with PD[6,16,23,28,31]. In any case, it ought to be viewed that the aftereffects of the included studies were conflicting and future examinations may change this case. To illustrate, four studies reported on muscle strength, two of which found significant improvement as compared to either no physiotherapy treatment or an active intervention[31,23] while two studies did not find significant gains[24,44]. These studies had programs containing resistance training.

Nonetheless, intensity was different among the trials. The studies that showed critical enhancement had programmes mainly focusing on muscle strength. While strengthening training, in other studies, represents a small portion of the programs. Consequently, the effect of physiotherapy on muscle strength should be further investigated.

Effects of physiotherapy on FOF

Fear of falling or FOF is additionally one of the fundamental contributing elements to the beginning of fall in individuals with PD and the discoveries of this paper support the use of physiotherapy to target fear of falling. Four studies analyzed the effect of physiotherapy intervention on this fear and these studies demonstrated critical positive outcomes for physiotherapy[21,22,25,33]. Distinctive interventions were utilized in these studies, including cueing training, balance exercise, and treadmill training.

Detectably, every one of the trials revealed enhancement in fear of falling and furthermore indicated enhancement in balance. This may show that impaired balance is a fundamental driver for the beginning of fear of falling and along these lines any enhancement as far as balance would prompt a lessening in this fear. In this way, it tends to have contended that any intervention is gainful because of a paranoid fear of falling if it enhances balance. This finding is like the evidence emerging from systematic reviews that concern the effects of physiotherapy on elders in general. For instance, Zijlstra et al. (2007)[54] reviewed 11 controlled randomized trials and indicated that different kinds of exercise programs, such as tai chi exercise and balance training have the potential to improve fear of falling in elderly people living in the community, although these studies were not planned explicitly to treat fear of falling.

Conclusion

Falling is one of the complications related to PD that affects up to 83% of sufferers. It creates the impression that this issue is likewise repetitive. Subsequently, a generous number of studies have been led to distinguish the factors that contribute to the onset of falls in this population and consequently several factors have been illustrated. These factors include previous fall history, impaired balance, gait problems, muscle weakness, poor performance in functional activities, depression, and FOF. However little work has been done in terms of fall prevention. The result of this study is promising. In any case, it appears that few controlled randomized trials haven't been done to examine the direct impacts of physiotherapy on fall. Despite this, there is proof that physiotherapy intervention may be useful in diminishing fall rate and near fall incidence among individuals with PD. However, the components of the interventions play a main role in the outcomes. According to the results of these studies, interventions that profoundly challenge balance are likely to have positive impacts on fall. However, more research is needed to support or refute this finding.

Furthermore, the results were also promising in that physiotherapy interventions have a positive impact on fall risk factors. Factors such as balance, functional mobility, FOF, and muscle strength may improve by physiotherapy. However, precisely the best interventions to focus on these factors stay questionable as make the long-term impacts of physiotherapy. One of the limitations of this paper is that most of the included studies barred individuals with other mental and neurological infections. In this manner, the generalizability of the discoveries can't be accomplished for those with PD and other cognitive impairments or different diseases. Furthermore, this scoping review aims to display trends in the literature without giving distinction to methodological quality or empirical 'weight'[55].

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