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Does Dual Task Training Improve Gait and Balance in People with Parkinson's Disease? A Systematic Review.

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I certify that all material in this dissertation which is not my own work has been identified and that no material is included for which a degree has previously been conferred to me.

Abstract

Title: Does dual task training improve gait and balance in people with Parkinson's disease? A systematic review.

Background: Parkinson's disease (PD) is a neurodegenerative disease and its prevalence is growing with increasing elder population. Gait and balance impairments are most disabling motor features of the disease and can lead to decrease in individuals' independency. Especially, under the dual task condition which performing two tasks simultaneously, both gait and balance performance are affected negatively because of the impaired motor and cognitive function coming from PD pathology. Physical therapy play an important role in the rehabilitation of the gait and balance features of the disease. Dual task training may be useful. However, there is an opinion that performing dual task can aggravate the fall risk in PD population. Although there is some evidence about the effects of dual task training on gait and balance, these are not specifically focused on gait and/or balance or PD population.

Objective: To systematically review available literature on the effects of dual task training on gait and balance in people with PD.

Data Sources: The systematic search of PubMed, MEDLINE, and PEDro was conducted to identify the relevant primary search. Further search was conducted by reviewing the reference lists of the included studies. the keywords: ‘‘Parkinson's disease OR Parkinson OR Parkinsonism’’ AND ‘‘dual task training OR concurrent task training OR dual task intervention OR concurrent task intervention’’ AND ‘‘gait OR balance OR walking OR stability’’ were used.

Study Selection: Quantitative studies, which are full-text accessible, were screened according to eligibility criteria and appropriate studies were included.

Data Extraction: Joanna Brigs Institute (JBI) Data Extraction form, which is designed for experimental/observational studies was used. EPHPP Quality Assessment Tool for Quantitative Studies was utilised as a risk of bias to evaluate the methodological of the primary research.

Results: Eleven studies were included. Five studies were strong evidence, two of them weak, and three of them were moderate evidence.

Gait Outcomes: Six studies investigated the gait outcomes; In general, improvements were seen gait velocity and stride length parameters. two studies showed significant improvements in gait velocity and stride length under dual task condition. Three studies found improvements in stride length, two of them found also in cadence under both single and dual task conditions.

Balance Outcomes: Five studies investigated the balance outcomes. A study found improvements in mediolateral and anteroposterior sway under dual task position. Two studies showed significant improvements in BBS and SOT scores.

Gait and Balance Outcomes: Two studies focused on both gait and balance parameters. one study found significant improvements in step length and gait velocity during normal walking and BBS score. The other study showed significant main effect of time for BBS and DGI scores.

Conclusion: Some strong evidence supports that dual task training improves gait parameters, especially gait velocity and stride length, under single and dual task condition. Dual task training can be support also balance performance in people with PD.

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Chapter 1: Introduction

Background

Parkinson's Disease

Parkinson's disease (PD) is a chronic neurodegenerative disease characterized by the loss of dopaminergic neurons in the substantia nigra leading to reduced levels of dopamine in the striatum and disrupted motor control (Elbaz et al., 2016). PD prevalence is relatively low among people, who are younger than 50 years of age in general and increases considerably with age in community-dwelling elderly and also, it is expected to grow causing a significant projected increase in the burden of PD, due to increases in the size of elderly populations (Darweesh et al., 2015).

The dopamine deficiency leading to dysfunction in the striatum, causes decreased activity in the direct pathway from GABAergic striatal neurons to the internal segment of the globus pallidus and substantia nigra pars reticulate and increased drive via indirect pathway, external segment of the globus pallidus. As a result, a disruption of the activity occurs in basal ganglia output structures, which in turn disrupts the activity in brain stem motor areas and this lead to difficulty in initiation of the movements and poor motion that are characteristics of PD (Hamani and Lozano, 2003).

Braak et al. (2003) have divided PD into six neuropathological disease stages. It is suggested that clinical symptoms of the disease develop in stage 3-4, and in the end stage (stage 5-6) a wide variety of clinical manifestations were seen (Sveinbjornsdottir, 2016). These manifestations in general are categorized as motor and non-motor clinical symptoms. The main symptoms include resting tremor, hypokinesia, rigidity, reduced amplitude of movement, and postural instability (Varalta et al., 2015). Addition to main symptoms, dystonia (continuous muscle contraction often accompanied by abnormal movements or postures or both) and oral motor disorders like speech disturbances can be seen in PD (Sveinbjornsdottir, 2016). Almost 25% of newly diagnosed PD patients present with cognitive deficits including visuospatial and executive functions, memory, and attention (Varalta et al., 2015). Fatigue, sleep, mood, pain, and autonomic disorders are other non-motor symptoms (Martinez-Martin et al., 2015).

Gait and Balance Impairments

Gait and balance disorders are two of the most disabling motor features of PD and play an important role in the progressive deterioration of patients' independency (Carpinella et al., 2017). According to Hoehn and Yahr (H&Y) scale, which is the commonly used scale for describing the symptom progression in PD, small changes in balance occur in the early stages of the disease but significant postural stability is described later; between H&Y stage two and three (Hoehn and Yahr, 1967). Balance impairments can be seen with increased postural sway in stance or increased double support time in gait (Curtze et a., 2016). The gait impairments include decreased coordination, freezing of gait (the inability to generate effective steps at the beginning of gait or the complete cessation of stepping during gait), hypokinesia (decreased speed with decreased step length), festination (decreased step length with increased cadence), decrease upper limbs balance, compensatory increase in speed and variability of steps, knee flexion in balance, plantar flexion at propulsion, decrease in hip width and extension at medium support phase (Earhart and Williams, 2012; Vieira et al., 2014). These gait and postural impairments are characterized also with reduced arm swing and loss of disassociated arm and trunk movements during walking (Barbosa et al., 2016).

While the reasons of these impairments are both disease-related changes and age-related changes such as muscle weakness and lower visual acuity, the other factor is cognitive function affecting the gait and mobility in PD (Christofoletti et al., 2016). These motor performances depend on the interaction between cognitive controls of movement in healthy people. In contrast, the early and preferential loss of dopamine in the dorsal basal ganglia causes diminished automatic and increased cognitive control of movements in PD. Eventually, people with PD should handle and maintain a larger cognitive load to execute either motor or cognitive task (Petzinger et al., 2013). This problem can be seen often while performing dual task, which is performing two different tasks at the same time. For example, individuals with PD reported that walking during performing another task is one of the major challenges in daily mobility (Kelly et al., 2012). When PD patients walking under dual task condition, they are more likely to decrease walking speed, and stride length, and show more freezing of gait episodes, compared to performing single tasks (Barbosa et al., 2016). Under dual task condition, the frontal lobes dedicate to the secondary task while gait is predominantly controlled by impaired basal ganglia, which makes dual task interferes negatively in gait (Vieira et al., 2014). This dual task interference can be explained in different theories; bottleneck theory and working memory theory, and resource sharing model. The working memory system draws on executive functions to coordinate allocation (multiple sources of information) of attention between concurrent tasks. Both attention and executive function impairments are seen in early PD and are related to dual task interference. Greater attention to walking and/or cognitive impairments in PD might therefore, result in disproportionately greater interference, because of reduced working memory capacity, dual task coordination deficit in working memory or inability to prioritize task properly (Rochester et al., 2014). The bottleneck theory can be explained with that to when performing two different tasks simultaneously, both require the same neural networks and this lead to delay in one of the tasks until those neural networks can be recruited again (Ruthruff et al., 2003). Another theory is the resource sharing model means that while performing simultaneous tasks, neural resources should be divided among them but when the capacity of these attentional resources is exceeded, hindering performance on one or both tasks, an interference with performing dual task may happen (Wu and Hallet, 2007).

Consequently, PD patients can face difficulties in mobility and especially dual task because dual tasks are requirements for most of daily life activities. In addition, all these impairments can lead to increased risk of falling, which can cause risk of injury such as hip fracture, reduced independency and quality of life (Earhart and Williams, 2012).

Management of PD and Dual Task Training

Management of the disease depends on the pharmacological treatment (levodopa is the long-term gold-standard) but still it is not enough for management of these gait and balance impairments because of the progressive nature of the disease, also gait and balance are non-dopaminergic features (Abbruzzese et al., 2016). Sometimes medication can even make the condition worse; two-thirds of falls appear during the on phase (when patients are under the effect of medication) (Cakit et al., 2007). In addition, long-term pharmacological treatments have some adverse effect such as levodopa induced dyskinesia and orthostatic hypotension (Borrione et al., 2014).

Therefore, motor rehabilitation is essential in the treatment and physical therapy is considered the most effective non-pharmacological treatment approach for PD patients (Carpinella et al., 2017; Borrione et al., 2014). There is some evidence about effectiveness of different physical therapy approaches on gait and balance in people with PD. Hass et al. (2012) found improvements in both gait and balance in people with PD after twice weekly 10 weeks progressive resistive training. A 4 weeks robot-assisted gait training improved gait speed and this effect continued for a month (Picelli et al., 2012). A Cochrane review (Mehrolz, 2015) showed that treadmill gait training improves gait speed and stride length. Furthermore, Rochester et al. (2010) found significant improvement in gait velocity and step length under both cued gait and non-cued gait condition after gait training with cueing strategies (auditory, visual, and somatosensory).

In general, there is mounting evidence for the role of exercise in developing motor performance, which may involve facilitating both automatic and cognitive control of movement (Petzinger et al., 2013). In this case, dual task training may be one of the appropriate motor rehabilitation methods to improve gait and balance impairments by improving both motor and cognitive function. Dual task training means performing a postural control task with a cognitive or motor tasks simultaneously as a training way (An et al., 2014). However, there is an idea that performing dual task can affect the gait performance or can be aggravated fall risk due to dual task interference.

Yogev et al. (2005) assessed the gait performance in PD patients and healthy older adults under single task (normal walking) and three different dual task conditions (walking while simple listening, complex listening, and serial seven tasks). They found decrease in gait velocity under dual task conditions compared with usual walking in both PD group and healthy older adult control group. This reduced gait speed in both groups may be related to age-related changes. However, gait variability significantly increased under dual task condition in the PD group only. They suggested that this change in gait velocity is a normal protective response to dual task in both PD and healthy group but the changes in gait variability express the possibility that regulating stride-to-stride variability is not an automatic process in PD but is an attention-demanding task.

Holmes et al. (2010) evaluated the participants'' who were twelve PD patients and twelve healthy age-matched people, postural stability under three conditions: without a secondary task, performing a rote repetition, and generating a monologue. They found that while both groups increased their postural excursion, people with PD showed significantly reduced excursion compared with those in healthy group. These can be explained with that PD may be over-constraining their postural adjustments to focus attention on the cognitive tasks without losing their balance. However, these over-constraints may lead to that participants can face greater risk for a fall. In addition, the findings demonstrated a significant effect of cognitive load on biomechanical dimensions of postural stability.

As a result, both gait and balance can be affected from dual task interference due to the pathology of PD (reduced motor and cognitive function) and can lead to risk for falls. On the other hand, there are some evidence about the positive effect of the practice of dual task in PD population.

Literature Review

A literature review was carried out for this project to identify what was already found in terms of the research question. For this literature review, key search terms were determined, and search was completed on PubMed, MEDLINE, and for reviews Cochrane Library databases. Also, a manual search was made on the electronic library of the university.

The used keywords were: ‘‘Parkinson’s disease or Parkinson or parkinsonism’’, ‘‘dual task training’’, ‘‘gait or balance or walking or stability’’. A time limitation did not used, and full-text accessible studies selected. The screening of the studies in terms of eligibility was made according to PICO search method. At the end of the screening nine studies included into literature review.

After the selection, two systematic reviews (Santos et al., 2016; Fritz et al., 2015), which investigated the effect of dual task training on gait performance in people with PD, and on mobility and cognition in people with neurological conditions respectively, one qualitative study (Leavy et al., 2017), five randomized controlled studies (Geroin et al., 2018; Strouwen et al., 2017; Perumal et al., 2017; Fernandes et al., 2015; Conradsson et al., 2015), and one non-randomized control study (Vanshika and Raja, 2012) included into the literature review.

Gait Outcomes

The literature search did not find any systematic review specifically referring to the research question. However, Santos et al. (2016) systematically reviewed the literature to investigate the effect of dual task interventions on just gait in people with PD. These dual task interventions varied. Thus, reaching a certain result about the effectiveness of dual task interventions may be difficult. They included seven studies, which used different kinds of dual task interventions. In three included studies, dual task gait training with different external markers (gait prioritization strategy or divided attention strategy between gait and cognitive tasks) or with external cues were used. In each study, some improvements in gait velocity under single and dual task conditions were seen. Improvements were seen also in cadence after external cue training. Stride length improved after dual task training with both type of instructions in two studies.

In three included studies, dance was used as a dual task intervention. Each study used Tango dance and two of them found significant improvements in gait speed and the other one found significant improvement in Timed Up and Go (TUG) test performance. Another study used walking with music strategy and observed significant increases in cadence and gait speed, and reduction in stride time under both single and dual task condition. Overall, Santos et al. (2016) found that different kinds of dual task interventions have beneficial effect on some gait parameters in people with PD. They stated that external markers play an important role on training effects on dual task gait performance.

A randomized trial (Strouwen et al.,2017) applied two different dual task trainings to two groups in total 121 PD patients and compared the effect of these two types of training during 6 weeks; integrated dual task training (IDT) (motor and cognitive task at the same time) and consecutive task training (CTT) (first half of the session just motor task training, and in the other part of the training, cognitive task training was given) on gait velocity in trained and untrained dual task conditions. They found significant improvements in gait velocity under both trained and untrained dual task conditions but there was no significant difference between two types of dual task training. These results showed that dual task training has beneficial effects on gait velocity, but gait velocity is not only dimension of the gait parameters. Geroin et al. (2018) investigated the effects of the same IDT and CTT on spatiotemporal gait parameters (e.g. cadence, stride length) in 121 participants. They found that cadence and stride length significantly improved under both single and dual task conditions and the improvements maintained at 12 weeks-follow-up. Similar with gait velocity results, there was no significant differences between IDT and CTT groups in terms of spatiotemporal parameters. furthermore, Strouwen et al. (2017) observed that fall rates of participants tend to drop during practice. Thus, they suggested that in contrast to current thinking, dual task training has not hazardous effect in terms of fall risk.

These two studies had randomized control study design, which can provide less risk of bias, and this factor make the study results reliable. They also had considerable sample size in terms of the generalizability of the findings. As a result, they suggested that dual task training can be a part of gait rehabilitation. On the other hand, balance is an important issue, which can lead to increase fall risk, for people with PD

Balance Outcomes

Fernandes et al. (2015) and Vanshika and Raja (2012) investigated the effect of dual task balance training. Vanshika and Raja (2012) applied 3 weeks- dual task balance training with fixed priority instructions or variable instructions to two groups by total 30 participants. They found significant improvement in Berg Balance Scale (BBS) score after dual task training with both type of instructions. Fernandes et al. (2015) compared the cognitive-balance dual task training and balance training under single task. They assessed the centre of pressure after 6 weeks training and observed improvement in mediolateral sway and anteroposterior sway in eyes closed position in dual task balance training group. Their sample size was in total 15. Although their findings give promising evidence about the effectiveness of dual task balance training as a therapeutic approach of balance rehabilitation, this small sample size may not lead to generalizing the findings. On the other hand, their study design was double-blind randomized trial. Thus, the risk of allocation bias less and the reliability of the findings can be high. Vanshika and Raja's (2012) study has small sample size like Fernandes et al.'s (2015) study and this situation can limit the generalization and significance of the statistical tests (Fernandes et al., 2015).

Balance and Gait Outcomes

Fritz al. (2015) explored the effectiveness of the motor-cognitive dual task training on both single task and dual task gait performance, and balance performance in people with different neurological disorders (PD, Alzheimer's disease, brain injury, stroke) and in elderly population. In the included studies, which investigated the PD population, significant improvements in gait parameters and balance under both single task and dual task conditions. Three studies showed that gait velocity and stride length significantly increased under single task position after dual task gait training. In addition, one of these three studies demonstrated that gait endurance improved via 6 Minute Walking Test. The significant improvements were found also in cadence. Similar improvements were observed in gait speed and stride length under dual task condition. Yogev-Seligman et al. (2012) reported that significant improvements in stride length and gait velocity were seen under also untrained dual task condition. Thus, they suggested that transfer of this training effect is possible.

Other three primary research assessed its effect on balance performance. Yen et al. (2011) found significant improvement in two dual task conditions (eyes closed on an unstable surface and eyes open on an unstable surface with visual surround) of the Sensory Organization Test (SOT). Mirelman et al. (2011) observed significant improvements in Four Square Step Test score and these improvements maintained at follow-up. However, Rochester et al. (2010) found no significant improvements in balance performance during the tandem stance.

As a result, Fritz et al. (2015) stated that dual task training may improve spatiotemporal parameters (e.g. stride length, gait velocity) in single task gait and dual task gait in people with PD.

Other studies were two randomized trials (Conradsson et al., 2015; Perumal et al., 2017) that focused on the effects of dual task balance training on both gait and balance outcomes in people with PD. Perumal et al. (2017) compared both two dual task training with different instructions and single task balance training. Both dual task groups and single task group improved Berg Balance Scale (BBS) and Dynamic Gait Index (DGI) scores after 4 weeks training. Although, they found significant changes in within group analysis for just DGI score, there was no significant change for balance (BBS score). They suggested that the reason can be the small sample size (total 36 participants) and shorter intervention time. Another limitation for this study was that they assessed the balance performance under just a single task position and they did not make a follow-up assessment.

Conradsson et al. (2015) applied 10 weeks HiBalance program, which includes dual task training with balance components, to experiment group and control group took usual care. They assessed both gait and balance. Significant improvements were found in Mini Balance Evaluation Systems Test (Mini-BESTest) score, gait velocity and step length during the normal walking in training group. They suggested that this balance training program significantly benefited balance and gait abilities. They had a relatively large sample size (total 100 participants) so, this is considered as a strength of the study in terms of determination the statistical significance of the results and generalization of the findings.

Another important aspect may be the perceptions of individuals with PD in these dual task gait and balance training as well all these motor results. It is suggested that patients' satisfaction in physiotherapy depends on the perception of biopsychosocial needs are met as well as the success of the therapeutic intervention because perception of change after physiotherapy may be regarded as subjectively perceived outcome of care (Normann et al., 2012). Therefore, this area also may be interesting to explore.

Although there is a lack of evidence, Leavy et al. (2017) explored the perception of people about the HiBalance program, which is highly challenging balance training including dual task exercises, with applying face-to-face interviews to 13 participants who had mild to moderate PD. They analysed the participants' perception in 3 subthemes: (1) movement to counter the disease, (2) dual task training in contrast to everyday strategies, and (3) the struggle to maintain positive effects. The first subtheme relates to how physical activity was used in a short term and long-term strategy releasing PD symptoms and their progression. The second subtheme relates to identified experiences of being maximally challenged in a secure and supportive group environment, circumstances that stood in contrast to participants' everyday lives. The third subtheme identifies participants' long-term struggle to continue program effects on cognitive and physical function in the face of disease progression.

All participants who had volunteered for the training program and attended in the interviews held positive beliefs in relation to the effects of physical activity on physical and mental function. Physical activity was considered in the ‘movement the counter to disease’ context as a short-term strategy to self-manage the disease by decreasing the provocation of unwanted motor symptoms and their results.

Taking one task at a time is considered as an every-day strategy by PD population because they compensate the decreased capacity to manage daily movements requiring a combination of motor and cognitive processes. Thus, taking slow and controlled approach was identified as an energy-saving strategy aimed at preventing muscular fatigue. A 66-year old man stated: ‘‘You know how you are supposed to do something, but to then get your mind and your muscles to understand that and get it down to your arms and legs, it doesn’t work automatically anymore, and that is hard. It’s like your brain doesn’t keep these things together anymore; it concentrates on the important parts… It’s better to take it slowly and surely and then things solve themselves… take it easy so that I can regain my energy and so that my muscles don’t get exhausted.’’

In this case, dual task exercises may be challenging for this population who has weakness in their individual capacity. Dual task exercises often were so demanding and resulted in feelings of accomplishment once completed. A 78 years-old woman: ‘‘Some of the things they showed us, they would say, “Do this, then do that, now off you go,” and I would think “But I will never be able to do that!” But it was so exciting to see if you could do it or not, there was a suspense, it was amazing…Then when you did manage to call out names and handle the ball at the same time, you felt like “Oh, did I just do that?” You felt like it was good for your brain as well.’’
Although most participants found dual task exercises challenging and exiting, the meaning of dual task performance could not transfer always to daily life. ‘‘The dual task exercises, they weren’t ones that you do in everyday life, they were a little more specific, and in a way challenging and exciting to do, but not movements that you can say that you have a lot of use for. (70-year-old man).

In terms of the struggle to maintain the training effects, participants were immediately aware of the challenges in continuing training effects in the long term. This situation may be related to gradual decline in physical capacity and also, psychological barriers such as reduced capacity to take initiative to exercise.

Rationale

It can be said that dual task training may promise improvement in gait and balance performance in people with PD. On the other hand, performing dual task can aggravate the fall risk due to impaired motor and cognitive function. Therefore, there is an uncertainty about whether individuals with PD should be taught to avoid performing dual task or should be them encouraged to practice performing dual task with expectations of enhanced performance (Brauer et al., 2011). When reviewed the literature, there is a lack of evidence to pool the findings into a certain result for contributing the literature or a guideline for clinical use.

For example, as mentioned above, Santos et al. (2016) conducted a systematic review but focused on the effect of dual task interventions on just gait performance in people with PD. However, balance performance is very important issue as well as walking for taking an attention in terms of preventing fall, performing daily life activities independently.

In addition, Santos et al. (2016) included seven studies; which had randomized or non-randomized controlled study designs, and they excluded studies, which has different design from controlled studies. RCTs place in the highest level in evidence hierarchy because they are formed to be unbiased and have less risk of systematic errors (Burns et al., 2011). Non-randomized controlled studies have fair quality in the evidence hierarchy (Evans, 2003). Therefore, risk of bias of their study may be relatively less and this situation can increase the reliability of their study because the study design plays an important role in minimising the risk of bias. On the other hand, they did not clearly demonstrate the quality of each study to decide which data is reliable for drawing into evidence because study design is not only factor influencing the methodological quality of a study. There are other factors such as attrition or data collection methods of each primary research in a systematic review. Thus, the reliability of primary research in this systematic review may not be clear. Furthermore, they searched the literature last time at the end of December 2015 and there are some studies conducted since then.

Fritz et al. (2015) investigated its effect on balance performance as well as gait parameters but the population was not specifically PD. Their population was people with neurological disorders (PD, stroke, brain injury, Alzheimer’s disease). Moreover, to date the studies, which investigated the effects of dual task training in people with neurological condition, had test-retest design, there was no enough amount of RCTs in literature. Therefore, they included some studies, which have not control groups, as well as RCTs. In addition, many of the included studies were weak in terms of methodological quality because of the lack of blinding and small sample size. For these reasons, it can be said that the quality of their systematic review may not be high.

Furthermore, when the reviewed the literature, the findings of the studies, which focused on balance outcomes, were not consisted. Therefore, a systematically reviewed article of the studies about the effects of dual task training on balance performance are needed.

As a result, a systematic review is need and this systematic review will focus on the effectiveness of dual task training for gait and balance in people with PD.

Research Question

Does dual task training improve gait and balance in people with Parkinson's disease?

Research Objectives

1) To investigate the effects of dual task training on gait and balance parameters in people with Parkinson's disease.
2) To understand whether dual task training decrease the effects of dual task interference during walking or balance control under dual task condition.

Outline of the research question was shaped utilising the PICOS method:

Population: people with PD
Intervention: dual task training
Comparison: PD patients; no intervention, different intervention from dual task training or different type of dual task training from those in experiment group

Outcomes: standard tests/scales specifically representing gait and/or balance parameters such as gait velocity, stride length, centre of pressure measurements, BBS, 6 Minute Walk Test

Study Design: randomized control trial or non-randomized control trials

Chapter 2: Methodology

Introduction

Evidence-based practice provides higher quality of care, improvement in patient outcomes and reduction in costs (Melynk et al., 2010). Therefore, to benefit from evidence in healthcare is important. However, to take the most appropriate and trustful data from each experimental study may not be always easy and accessible. In this case, systematic reviews may be very beneficial because they are suitable summaries of evidence for healthcare practitioners (Moher et al., 2007).

A systematic review is a literature review, which has clearly formulated a research question and uses systematic explicit methods to identify, select, and critically appraise relevant research from published studies related to the question (Ham-Baloyi and Jordan, 2016). The main characteristic of systematic reviews is that they use a meticulous set of criteria by which to appraise the validity and reliability of previously published research (Ham-Baloyi and Jordan, 2016).

In addition, systematic reviews are known as a gold standard, especially when they are formed from randomized controlled studies, mainly for judging the benefits of treatments because it is conceptually easier to attribute any observed effect to the treatments being compared (Barton et al., 2000).

On the other hand, a systematic review should be methodologically well-designed to improve its reliability. Overall, to prepare a well-structured systematic review and reduce risk of bias systematic review should include clear aims with relevant criteria for the studies; clear and reproducible methods; meticulous search design; an assessment of validity of the included studies, and a systematic presentation and synthesis of the included studies (Clarke, 2011). To provide these elements, a structured study protocol and to follow checklists or guidelines such as The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and The Centre for Reviews and Dissemination (CRD) during the designing and writing process may be useful. For this systematic review, the PRISMA (2009) checklist items were followed during the writing process (Appendix 1).

This review aimed to show the effects of dual task training on balance and/or gait performance in people with PD by including the quantitative studies. The Cochrane

Library database was searched whether published any systematic review, which related to the research question study to be sure.

Eligibility Criteria

Eligibility criteria is important in terms of the including the relevant studies into the review as a priori definition of the literature. They are fundamental to the validity of a systematic review and framed by the research question and applied throughout the search strategy to the final set of studies for review (McCrae et al., 2015).

For this review eligibility criteria were established basing on the PICOS (Population, Intervention, Comparison, Outcome, and Study design) strategy to rigorously determine the relevance of the studies and obtain the most appropriate papers according to the research question. In addition, language of the studies was the other eligibility criteria. The inclusion and exclusion criteria with their rationale were demonstrated on Table 2.

Table 1: Eligibility Criteria

Criteria / Categories	Inclusion Criteria	Exclusion Criteria
Population	People with Parkinson's disease.	People with Parkinson's disease also any other neurological condition or mental problem.
Rationale	Any disease like Alzheimer's disease or any other neurological condition, which is addition to Parkinson's disease, can lead to interpret the results in terms of investigating of the intervention effect on PD.	
Intervention	Refers to any dual task gait training and/or dual task balance training.	Do not refer to dual task training or additional intervention with dual task training.
Rationale	The type of dual task gait and balance training were not limited due to the potential lacking studies. On the other hand, an additional intervention to dual task training can	

	lead to interpret the effect of dual task training and increase risk of bias.	
Comparison	PD patients, who took different intervention from dual task training or different type of dual task training from those in experiment group or no intervention.	Healthy people or no comparison group.
Outcomes	Specifically represents the gait parameters such as step length, cadence, gait speed and standard tests/ scales like 6-minute Walk Test (6mWT); or balance performance tests/ scales like Berg Balance Scale (BBS)	Do not clearly represent any gait or balance assessment.
Rationale	To provide the clinical relevance outcomes for research question.	
Study Design	Randomized controlled studies (RCTs) or non-randomized controlled studies	Other study designs rather than controlled studies such as case studies or cohort studies.
Rationale	RCTs are the most reliable designs in the evidence hierarchy and controlled studies follow them. Due to the potential of lacking the RCTs, controlled studies are also eligible for this review.	
Language	English or Turkish	Non-English or non-Turkish
Rationale	Limited resources of translation	

Search Strategy

The search strategy was performed rigorously. Electronic databases PubMed and MEDLINE (EBSCO), which have the medical and healthcare literature, were used. In addition, PEDro was used as it includes over 40.000 of clinical trials, systematic reviews, and guidelines in specifically physiotherapy. MEDLINE can provide MeSH terms, therefore, it is sensitive for finding all relevant studies and it was chosen (Centre for Reviews and Dissemination (CRD), 2009). Although PubMed does not provide thesauri, this database includes more than 20 million citations and 2000-4000 more added every day (Agoritsas et al., 2012). Therefore, PubMed was also a good database and chosen. For this process, a search strategy was established according to research question with an information specialist's support from the university and some specific search terms were used (Table 1).

Table 2: Search Terms

Population		Intervention		Outcomes
Parkinson's disease OR Parkinson OR Parkinsonism	AND	Dual task training OR Dual task intervention OR Concurrent task training OR concurrent task intervention	AND	Gait OR Walking OR Balance OR Stability

During the database searching, no time limitations were applied. A search was performed for the last time at the end of the May 2018. Further searches were completed by reviewing the reference lists of the included studies.

Study Selection

The found studies were reviewed according to their titles and abstracts. The duplicated studies were removed via Mendeley-Reference Management Software. Accessible full-text articles were comprehensively viewed according to eligibility criteria. This process should be executed by at least two researchers to ensure the reliability and minimise the risk of bias, but study selection was completed by the author because of the limited time for this review.

Data Extraction

Data extraction should be executed in duplicate, with involvement of the third reviewer or disagreements resolved by a consensus (Da Costa and Jüni, 2014). However, due to time restrictions, data extraction was completed by the author. The use of a standardised data extraction form can provide consistency in a systematic review by reducing bias and increasing reliability and validity. Also, the form should follow the broad format taking account of necessary adaptations (CRD, 2009). In this systematic review, Joanna Brigs Institute (JBI) Data Extraction form, which is designed for experimental/observational studies (Appendix 2) was used and it was tailored according to the research question.

Quality (Risk of Bias) Assessment of the Studies

When the raw data of the included studies was defective, the results of the review cannot be trustful. Thus, the methodological quality assessment of the eligible studies always should be conducted (Da Costa and Jüni, 2014). Quality is a multidimensional concept, which can be related to the design, conducting, and analysing of a trial, its quality of reporting or clinical relevance (Jüni et al., 2001). The potential reasons of the bias in a clinical trial results may be lack of blinding of therapists, patients, or outcome assessors, inappropriate concealment of allocation, or analysis not according to the intention to treat analysis principle (Jüni et al., 2001; Wood et al., 2008). The certain bias type and their brief explanations were stated below (Abbas et al., 2008).

- Selection Bias: It accounts for the systematic differences between the baseline features of the compare groups.
- Performance Bias: It accounts for the systematic differences between the groups in the given care or in exposure to issues other than the interventions of interest.
- Attrition Bias: It accounts for the systematic differences between the groups in study withdrawals.
- Detection Bias: It accounts for the systematic differences between groups in determining the outcomes.

- Reporting Bias: It accounts for the systematic differences between the unreported and reported findings.

Checklist may be a reliable way to ensure that all the included studies assessed critically appraised in a standardised way (CRD, 2009). In general, these checklists can tend to be specific to certain study designs such as Cochrane Collaboration Risk of Bias Tool for RCTs and The Risk of Bias Assessment tool for Non-Randomised Studies (RoBANS) (Harrison et al., 2017; CRD, 2009). Therefore, when the review includes more than one type of study design, separate checklists can be used for each study design, or combined lists selected or developed (CRD, 2009).

The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (2010), which includes eight components, is one of these tools. This tool can be used not only for RCTs but also for before and after studies, observational and cross-sectional studies. Its use is appropriate for this systematic review because the design of the included studies was both RCT and non-randomized control trial. In addition, the EPHPP showed fair inter-rater agreement for individual domains and excellent agreement for final grade (Armijo-Olivo et al., 2012). For these reasons, the EPHPP quality assessment tool was used in this systematic review (Appendix 3). Quality assessment of the primary research play a crucial role in terms of minimising the bias and maximising the precision of a systematic review (Abbas et al., 2008). Therefore, to prevent the human error and increase the reliability of the review, quality assessment should be done by at least two independent assessors. This assessment was completed by the author due to the time restrictions.

Data Synthesis

Synthesis includes the collation, combination and summary of the findings of primary studies in the systematic review and it can be done quantitatively using statistical methods like meta-analysis or when this kind of method is not appropriate, it can be done via narrative approach (CRD, 2009).

For this systematic review, the data, selected through the data extraction process (study design, sample size, participants' mean age and disease severity, assessment period, intervention, outcome measurements, and key findings), was recorded and then investigated to determine the synthesis approach. There was a heterogeneity between the types of dual task training in the included studies also these studies had different study design. Therefore, quantitative analysis like a meta-analysis was not appropriate and narrative approach was used.

<u>Ethical Consideration</u>

Ethical approval is not necessary for the systematic review because systematic reviews did not require participants' information. However, when a systematic review included an ethically insufficient primary research, this situation can lead to publish unethical study and also be prone to conflict of interest (Vergnes et al., 2010). Therefore, ethical issues of the included studies were taken attention.

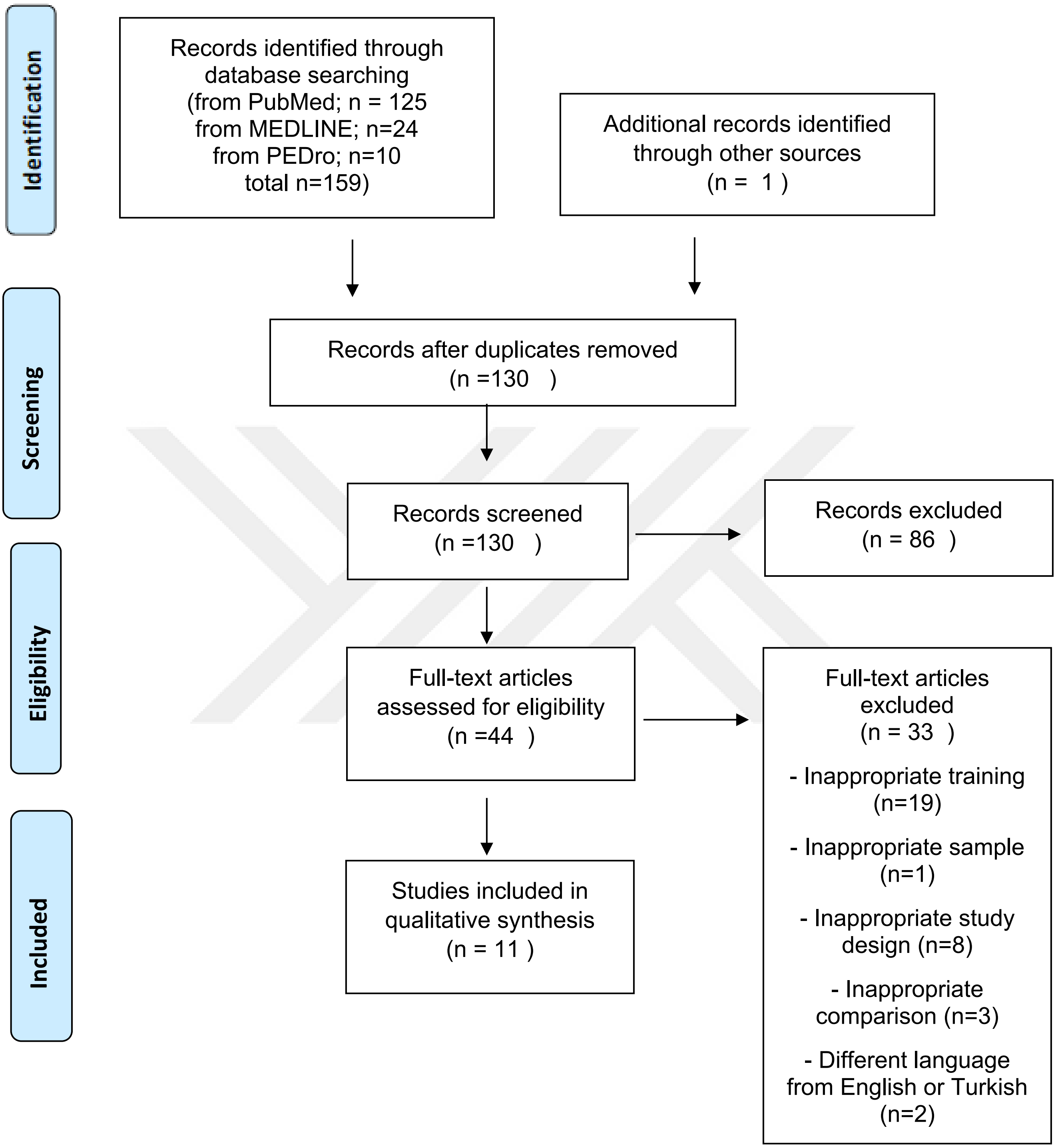
Chapter 3: Results

In this chapter, the descriptive features of identified studies, used interventions types and outcome measurements, risk of bias assessment of included studies, and main results of the studies were explained.

Identified Studies

Firstly, electronic databases (PubMed, MEDLINE (EBSCHO), and PEDro) were used and 159 studies identified. thirty of duplicated studies were removed. The remained 129 studies screened by reviewing titles and abstracts of them and 86 studies removed due to being irrelevance. Forty-three of full-text articles were reviewed in a comprehensive manner to assess their eligibility. Thirty-three articles were excluded because of some specific reasons, showed in detailed on Figure 1. After the screening of the studies, 10 articles, which met all eligibility criteria, remained. During the reviewing the references of these obtained articles, one relevant study was found and ultimately, 11 studies were included into this systematic review at the end of the process. This process was demonstrated on Figure 1 below. Figure 1 is a PRISMA Flow Diagram, which presents the flow of information through the different stages of the systematic review and demonstrating the number of records identified, included and excluded, and the reasons of exclusions.

Figure 1: A PRISMA Flow Diagram of Study Identification Process



Descriptive Analysis of Identified Studies

The characteristics and main results of included studies are illustrated in three different tables: Table 3, Table 4, and Table 5. These three tables were prepared according to focused outcomes of the studies so that the detailed information can be easily followed; Table 3 presents studies focused on gait outcomes, Table 4 presents studies focused on balance outcomes and Table 5 presents studies focused on both gait and balance outcomes. The study designs of the included studies are varied: two studies were randomized controlled trial (Conradsson et al., 2015 and De Bruin et al., 2010), five of them were randomized clinical trial (Geroin et al., 2018, Strouwen et al., 2017, Perumal et al., 2017, Fernandes et al., 2015, and Yen et al., 2011). While two studies had test-retest design with control group (Fok et al., 2010 and Fok et al., 2012), two studies had a quasi-experimental design (Vanshika and Raja, 2012, Mirelman et al., 2011).

Table 3:The detailed information of studies focused on gait

Study/year	Design	Sample Size/ Characteristics	Medication	Interventions	Comparison interventions	Measurements	Main results
Geroin et al. (2018)	single-blind randomized clinical trial	CTT group: 65 participants IDT group: 56 participants Age (mean); CTT:66.05 IDT:65.80 H&Y stage 2-3	ON	IDT training 30 min IDT plus 10 min functional training each session; twice/week; 6 weeks	CTT training 15 min motor task training plus 15 min cognitive task training plus 10 min functional training each session; Twice/week; 6 weeks	Spatiotemporal parameters; stride length, cadence, standard deviation of stride length, etc. In both single task condition and three different dual-task condition; an auditory stroop task (untrained), a backward digit span task (trained), and use of mobile phone (untrained). At baseline, second baseline (after 6 weeks interval), post-intervention, and 12-weeks after	Stride length and cadence significantly improved in both single task and dual-task conditions (P<0.001). These improvements maintained at 12 weeks-follow-up. There was no significant change for gait variability under both tasks conditions. Both training modalities had similar effects on spatiotemporal parameters.

Strouwen et al. (2017)	A single-blind randomized clinical trial	CTT group: 65 participants IDT group: 56 participants Age (mean); CTT group:66.05 IDT group:65.80 H&Y stage 2-3	ON	IDT training 30 min IDT plus 10 min functional training each session; twice/week; 6 weeks	CTT training 15 min motor task training plus 15 min cognitive task training plus 10 min functional training each session; Twice/week; 6 weeks	-Gait velocity during Stroop task (untrained) -Gait velocity while performing a backward digit span task (trained) -Gait velocity while using a mobile phone At baseline, second baseline (after 6 weeks interval), post-intervention, and 12-weeks after	Significant improvements (P <0.001) in dual-task gait velocity in all trained and untrained dual tasks. Improvements ranged between 7.75% and 13.44%.
Fok et al. (2012)	Test-retest design	Training group: 6 participants Control group: 6 participants Age (mean); Training group:73.0 Control group:66.3	ON	30 min one session dual task training with divided attention in taking big steps	No intervention; sitting down and reading magazine	-gait speed -stride length Assessments were applied in both single and dual task conditions; at baseline, post-training, and 30-minute after training(retention)	Gait speed and stride length improved (P: 0.04 and P:0.005 respectively) immediately after training. improvements in both gait speed and stride length (P:0.03 and

		H&Y stage: 2.8 (mean) for training group, 2.8 (mean) for control group					P:0.03) in training group 30 min after training
Mirelman et al. (2011)	Quasi-experimental study based on retrospective control group	Experimental group: 20 participants Age (mean); Experimental group:67.1 H&Y stage:2-3	ON	TT plus VR Progressive intensive treadmill training with VR 45 minutes/session,3 sessions/week, 6 weeks (5minute warm-up)	TT (without VR)	-Gait speed -Stride length -Stride time -6mWT Assessments were applied in three conditions; walk at a comfortable pace, walking while serial 3 subtractions (dual task position), walking while negotiating two obstacles At pre-training, post-training, 4-weeks follow-up	Significant improvements in gait speed (P: 0.032), stride length (P: 0.016), and stride time (P: 0.046) in dual task condition and continued at follow-up. There was an improvement in 6mWT (P: 0.004) by a mean of 17% distance walked, continued at follow-up.
De Bruin et al. (2010)	Randomized controlled study	MUSIC group: 16 participants	ON	30 minutes walking at a comfortable pace	Regular activities during 13 weeks	-Gait speed -Cadence	Significant increase in gait velocity (P: 0.002)

		Control group: 17 participants Age (mean); MUSIC group:64.1 Control group:67.0 H&Y stage: 2-3		while listening self-selected music plus regular activities 3 times/week, 13 weeks		-Stride time Assessments were applied in both single and dual task conditions, at baseline and post-intervention.	and cadence (P: 0.007) and decrease in stride time (P: 0.019) in MUSIC group. No time-by-task interaction favour of DT (P>0.05).
Fok et al. (2010)	Test-retest design	Training group: 6 participants Control group: 6 participants Age (mean); Training group:66.8 Control group:57.7 H&Y stage: 2.8 (mean) for training group,	ON	30 min one session dual task training with prioritization of taking big steps	No intervention; sitting down and reading magazine	-Gait speed -stride length Assessments were applied in both single and dual task conditions; at baseline, post-training, and 30-minute after training(retention)	Improvements in gait speed and stride length (P:0.04, P:0.005 respectively) immediately after training. The improvements continued at 30 min after training in both single task and dual task conditions when

		2.5 (mean) for control group					compared with control group.

Abbreviations: CTT: consecutive task training; H&Y: Hoehn and Yahr Scale; IDT: integrated dual-task training; TT: treadmill training; VR: Virtual Reality; 6mWT: 6 minutes Walking Test.

Table 4: The detailed information of studies focused on balance

Study/year	Design	Sample	Medication	Interventions	Comparison interventions	Measurements	Main results
Fernandes et al. (2015)	Randomized clinical trial	Dual task group: 8 participants Single task group: 7 participants Age (mean); Dual task group:63.4 Single task group:62.3	ON	Dual task (cognitive+ balance) training 60 min per session; twice a week for 6 weeks	Single (balance) task training 60 min per session; twice a week for 6 weeks	-TUG -COP At baseline and post-training	An improvement in mediolateral sway (P: 0.026 , size effect:1.094) and anteroposterior sway (P: 0.029, size effect:1.430) in eyes closed position in dual task training group. No significant improvements in

		Modified H&Y stage:3					single task group for COP (P>0.05)
Vanshika and Raja (2012)	Quasi-experimental design	Group A: 15 participants Group B: 15 participants Age (mean); Group A:66.27 Group B:66.67 H&Y stage:1-3	Cannot tell	For group A: Dual task balance training with fixed priority instructions 45 min/session 5 times per week for 3 weeks	For group B: Dual task balance training with variable instructions (in the half of the training, participants focused on cognitive task, in other half of training, postural tasks) 45 min/session 5 times per week for 3 weeks	-BBS At baseline and post-training	Significant improvement in BBS (P: 0.000) in both groups. improvements were greater in group B than those in Group A.
Yen et al. (2011)	Randomized controlled trial	VR group: 14 participants, CB group: 14 participants,	ON	VR group; 10 min stretching plus 20 min standing on the VR balance	CB group;10 min stretching plus 20 min conventional therapy, which is	-SOT Assessments in different conditions; single	Significant improvement in the equilibrium score of SOT5

		Control group: 14 participants Age (mean); VR group:70.4 CB group:70.1 Control group:71.6 H&Y stage:2-3		board and trying to navigate the dynamic balance board moving their weight with the use of ankle strategy 2 times/week, 6 weeks	focused on static balance, dynamic weight shifting, external perturbations Control group; No intervention 2 times/week, 6 weeks	primary task (SOT) while standing, single secondary task while sitting (cognitive task: auditory arithmetic subtraction task), dual tasking (SOT with cognitive task) while standing At baseline, post-training, week 4 follow-up	condition (eyes closed on an unstable surface) and SOT6 condition (eyes open on an unstable surface with visual surround) in both VR and CB group when compared with control group (P<.001). there were no differences between VR group and CB group.

Abbreviations: BBS: Berg Balance Scale; COP: centre of pressure; CB: conventional balance training; SOT: Sensory Organization Test; TUG: Timed Up and Go test; VR: Virtual Reality training

Table 5: The detailed information of studies focused on balance and gait

Study/year	Design	Sample	Medication	Interventions	Comparison interventions	Measurements	Main results
Perumal et al. (2017)	Randomized clinical trial	Group 1: 12 participants Group 2: 12 participants Group 3: 12 participants Age (mean); Group 1:68.75 Group 2:68.17 Group 3:67.75 Modified H&Y stage:3-4	Cannot tell	Group 3: dual task balance training (instructured to focus on the postural task during the half of the training, during the other half of training, they were instructured to focus on cognitive task) 45 minutes/session, 3 times/week, 4 weeks	Group 2: dual task balance training with instructions to focus on both two tasks. 45 minutes/session, 3 times/week, 4 weeks Group 1: single task balance training 45 minutes/session, 3 times/week, 4 weeks	-BBS -DGI at baseline and post-training.	In between-subject analysis, no significant main effect of groups for both DGI and BBS (P>0.05) Significant time-group main effect of DGI scores (P<0.05), but no significant interaction effect for time-group scores of BBS (P>0.05) There was a significant main effect of time,

							for DGI and for BBS (P<0.05)
Conradsson et al. (2015)	A randomized controlled trial	Training group: 51 participants Control group: 49 participants Age (mean); Training group:72.9 Control group:73.6 H&Y stage:2-3	ON	HiBalance training program (dual-tasking with balance components 60 min per session; 3 times/week for 10 weeks	Normal physical activities	-gait velocity -step length -cadence Under single and dual task conditions -Mini-BESTest -MFE All assessments were applied at baseline and post-intervention	There was a significant improvement in balance and gait during normal walking in training group (Mini-BESTest: 3 points; gait velocity: 0.1 m/s; step length: 0.04 m)

Abbreviations: BBS: Berg Balance Scale; DGI: Dynamic Gait Index; HiBalance: Highly challenging balance program; MiniBESTest: Mini- Balance Evaluations Systems Test; MFE: Modified Figure of Eight test.

Participants Characteristics

In all studies, Hoehn and Yahr Scale (H&Y) or Modified H&Y scale were used to assess the disease severity. In all studies, participants' disease severity represented mild to moderate severity according to H&Y scale stage:2-3, and Modified H&Y scale stage: 2.5-3.5. In addition, they had not cognitive impairment according to Mini Mental State Examination Test (MMSE) (scores were >24 or ≥24). The participants' mean age varied from 57.7 to 73.6.

Type of Interventions

According to the objectives of the studies, their intervention types can be divided into dual task gait training and dual task balance training. However, they had different styles like using music or instructions.

Dual task gait training

Both Strouwen et al. (2017) and Geroin et al. (2018) applied dual task gait training in home-setting with a physiotherapist's led. An integrated dual task training (motor and cognitive task at the same time) during the session for one group. The other group took dual task exercises consecutively (first half of the session included just motor task training, and in the other part of the session, they took cognitive task training). Motor tasks depended on improving gait quality (taking big steps, focusing on heel strike, turning, tandem walking, etc). The cognitive tasks included discrimination and decision-making tasks, verbal fluency tasks, mental tracking tasks, working memory tasks, and reaction time tasks (Strouwen et al., 2014).

Dual task training with balance components

Fernandes et al. (2015) applied a dual task training including cognitive activities (digit span, spelling words, image description, nomination, counting) and balance components based on gait without manipulation, gait manipulation activities, stability without manipulation, and stability with handling. Conradsson et al. (2015) investigated both gait and balance but their intervention was similar with Fernandes et al.' (2015) study. The dual task training combined with balance components. They added dual task exercises progressively into program and increased the difficulty level of both balance exercises and cognitive exercises.

Dual task gait training and dual task balance training with instructions

Fok et al. (2010) gave instructions to participants. During the gait training under dual task condition (walking with counting backwards by threes), patients were asked to give prioritization on taking big steps (2010). In the other study (Fok et al., 2012), participants were asked to focus equally on both taking big steps and counting in the same dual task condition.

Vanshika and Raja (2012) and Perumal et al. (2017) used dual task balance training with instructions. Perumal et al. (2017) gave instruction the participants to focus on the postural tasks during the half of the training and in the other half, they were instructed to focus on the secondary task in one group. Secondary task includes some daily life activities such as carrying a bag, listening, speaking, making a shop list and cognitive activities such as counting backwards, calculation, spelling words backward. These secondary tasks integrated gradually into the balance training activities like tandem or semi-tandem walking. The participants in other group performed the same tasks but their instructions were to focus on both two tasks during the training. Vanshika and Raja (2012) applied the similar training. The instructions were about variable prioritization (in the first half of the training focusing on postural task and in other half of the training, focusing on cognitive task in one group. The other group were instructed with fixed priority.

Dual task training; Music

De Bruin et al. (2010) used self-selected music as a secondary task during walking at a comfortable pace.

Dual task gait and balance training; Virtual Reality

Yen et al. (2011) used Virtual Reality-augmented balance training. Patients tried to navigate dynamic balance board by moving their weight to control the simulated board in the virtual environment. Participants were asked to use ankle strategy. VR games were applied in a certain order: 3D ball-rolling game requiring moving in same direction, outdoor activities requiring straight and circular movements, and indoor activities including requiring multiple turning.

Mirelman et al. (2011) applied treadmill training with Virtual Reality (VR) to improve gait performance in both single task and dual task conditions. Participants tried to make decisions about visual obstacles negotiation during the walking on a treadmill.

For VR simulation the speed, size, orientation, frequency of appearance, and shape of target were determined according to the needs of the participants. In addition, the difficulty of virtual tasks was progressively increased with distracters such as moving objects in simulation or size of the visual obstacles, when a patient was able to complete the task in a trial.

Types of intervention for comparison groups

Some studies did not apply any intervention (Fok et al., 2010, Fok et al., 2012). While in some studies, participants in control group performed normal physical activities (De Bruin et al., 2010, Conradsson et al., 2015), some studies applied single task training to comparison group (Perumal et al., 2017, Fernandes et al., 2015). Yen et al. (2011) used conventional balance training for comparison group and no intervention for control group. Treadmill training (TT) without VR was selected as a comparison intervention in a study (Mirelman et al., 2011)

Type of Outcome Measurements

Gait parameters such as gait velocity, step length, cadence, stride length were evaluated with GAITRite Walkway system. For balance assessments, Mini- Balance Evaluations Systems Test (MiniBESTest), Dynamic Gait Index (DGI), Berg Balance Scale (BBS), Timed Up and Go (TUG) test, and Modified Figure of Eight test (MFE) were used. In addition, centre of pressure (COP) was assessed with a pressure platform for postural balance.

Quality Assessments

EPHPP quality assessment tool for quantitative studies was used for this systematic review. The rates of each content and overall rates for each study were showed in Table 6. Two studies were weak mainly due to lack of blinding, selection bias, and analysis (Vanshika and Raja, 2012, Mirelman et a., 2011). Three studies had moderate quality due to the lack of blinding (Fok et al., 2010, Fok et al., 2012, Perumal et al., 2017). Six studies were marked as strong (Geroin et al., 2018, Strouwen et al., 2017, De Bruin et al., 2010, Conradsson et al., 2015, and Fernandes et al., 2015, Yen et al., 2011). All studies were moderate or weak in terms of blinding except Fernandes et al.' (2015) study because both their outcome assessors and participants were blind. Majority of the studies (except Conradsson et al., 2015, Strouwen et al., 2017, Geroin et al., 2018, and Yen et al., 2011) were moderate in terms of analysis and the main reason of this was that they did not use intention to treat analysis method, though there is a risk of the facing of missing data.

Table 6:Quality ratings of included studies according to EPHPP

Components / Study	Geroin et al. (2018)	Perumal et al. (2017)	Strouwen et al. (2017)	Conradsson et al. (2015)	Fernandes et al. (2015)	Fok et al. (2012)	Vanshika and Raja et al. (2012)	Mirelman et al. (2011)	Yen et al. (2011)	Fok et al. (2010)	De Bruin et al. (2010)
Selection Bias	1	1	1	1	1	1	2	3	1	1	2
Study Design	1	1	1	1	1	1	1	1	1	1	1
Confounders	1	1	1	1	1	1	1	3	1	1	1
Blinding	2	3	2	2	3	3	3	3	2	3	2
Data Collection Methods	1	1	1	1	1	1	1	1	1	1	1
Withdrawals, Drop outs	1	1	1	1	1	1	1	1	1	1	2
Intervention Integrity	2	2	2	2	2	2	2	2	2	2	2
Analyses	2	2	2	2	2	2	2	2	2	2	2
Overall	1	2	1	1	2	2	3	3	1	2	1
Rating Means	1= Strong, 2= Moderate, 3= Weak										

Main Findings

Each study investigated the effects of dual task trainings on balance and gait performance in different conditions (single task condition or dual task condition or both). Therefore, the findings were synthesised in these conditions so that easily analyse the results.

Single Task Gait

Geroin et al. (2018) significant improvements in stride length and cadence ($P<0.001$) in single task position in both CTT group and IDT group. Post-hoc within-group comparison showed that these significant increases in stride length and cadence were seen after treatment and at 12-weeks follow-up. For gait variability, there was no significant effect in single task position. In addition, there were significant decrease in stride time, stance time and double-support percentage.

Fok et al. (2010; 2012) showed significant improvements in stride length and gait speed immediately after training and 30 minutes after in single task condition after both dual task training by prioritizing the one task (2010) and dividing attention during dual task (2012) when compared with null control.

De Bruin et al. (2010) found significant increase in gait velocity (2.34%) and cadence (1.74%) and decrease in stride time (1.42%) in single task position after 13-weeks walking with music program.

Conradsson et al. (2015) found highly significant improvements in gait velocity and step length during normal walking ($P<0.001$) after 10-weeks HiBalance program compared with control group taking usual care.

Dual Task Gait

When compared with control group, which did not take any interventions, dual task gait speed and stride length significantly improved after dual task training with prioritization or dividing attention therapy, and the improvements continued at follow-up (Fok et al., 2010, Fok et al., 2012).

De Bruin et al. (2010) found significant improvements for velocity, cadence, and, stride time ($P<0.005$). There was an increase in cadence (6.86%) and gait speed (6.68%), and a decrease in stride time (6.86.5) in dual task condition after music-walking intervention.

Geroin et al. (2018) found significant improvement in stride length in all three dual task conditions; auditory stroop task, backward digit span task, and mobile phone task ($P<0.001$). These improvements maintained at follow-up, but the effects slightly decreased. The improvements were also in cadence in for all three dual task conditions ($P<0.001$). These improvements continued at follow-up in the mobile phone task condition ($P<0.001$). In addition, there was a significant decrease in stride time, stance time and double support percentage for mobile phone task condition. There were no significant differences between CTT and IDT. Gait variability was assessed by comparing stride time and stride length variability. Gait variability was found significant in terms of stride length on the backward digit span task ($P<0.005$) and the main effects for time in terms of stride time variability in auditory stroop task condition were found significant ($P<0.005$).

Strouwen et al. (2017) showed that there was a significant increase in dual task gait speed for both trained dual task condition (backward digit span task) and untrained dual task conditions (stroop task and mobile phone task). These improvements sustained at follow-up. Furthermore, there was no time-group interaction effect. So, CTT and IDT had similar effects on gait speed in dual task conditions.

In favour of dual task gait speed, step length, and cadence there was no interaction effects in Conradsson et al.' (2015) study.

Mirelman et al. (2011) demonstrated that there were significant improvements for gait speed, stride time, and stride length ($P<0.005$) in dual task condition. They compared these results with the control group from previous study (Mehrolz et al., 2010) and found that the gains in gait speed and stride length were significantly larger in recent study than those in the previous study.

Balance

Fernandes et al. (2015) assessed the centre of pressure (COP) in terms of anteroposterior (COPy) and mediolateral (COPx) directions. Significantly important improvements were found in COPx (P: 0.026) and COPy (P: 0.029) in eyes closed position in dual task balance training group compared with single task balance training group.

Vanshika and Raja (2012) showed significant improvements in BBS score (P: 0.000) after both dual task training with fixed priority instructions and dual task training with variable instructions programs. The improvements in dual task training with variable instructions group was greater than those in dual task training with fixed priority instructions group.

Perumal et al. (2015) used similar intervention with Vanshika and Raja' (2012) training program and found significant main effect of time similar with Vanshika and Raja (2012) for BBS and also for DGI scores ($P<0.005$). Significant time-group effect was observed on DGI scores ($P<0.005$). However, in contrast to Vanshika and Raja's (2012) study results, there was no significant differences between dual task group with fixed priorities and dual task group with variable priorities in terms of both DGI and BBS scores. In addition, they did not observe any significant differences between single task balance training group and both dual task training groups in terms of BBS and DGI.

Conradsson et al. (2015) found significant interaction effect for MiniBESTest (P: 0.001), meaning that there was a significant improvement over time (by 3 points) in MiniBESTest score in dual task balance training group.

Yen et al. (2011) found significant improvement on the equilibrium scores of SOT in condition-5 (eyes closed on an unstable surface) and condition-6 (eyes open on an unstable surface with visual surround) in the VR group over the null control group.

Chapter 4: Discussion

The aim of this systematic review was to understand whether dual task training improves gait and balance parameters in both single task condition and dual task condition. The relevant studies were selected, and they included different dual task training modalities and they reached different amount of improvements or different results in different task conditions.

The one of ways to improve both normal walking and dual task walking may be to provide or support the motor learning in PD patients. The motor learning includes two phases; firstly, skill is acquired over short term and then retained into long-term memory with repeated practice over several weeks, so, performance can emerge automatically (Rochester et al., 2010). Therefore, performing several practices for gait in single task position or for both gait/balance and secondary task (motor/cognitive) in dual task position may prompt the automaticity and may support to improve gait and balance performance in both single task and dual task conditions.

The two of the included studies (Geroin et al., 2018, Strouwen et al., 2017) applied consecutive task training (CTT) to one group and integrated dual task training (IDT) to other group in same manner. Strouwen et al. (2017) found significant improvements in gait velocity in different dual task conditions. Similarly, Geroin et al. (2018) showed significant improvements in stride length and cadence in both single task and dual task conditions. There were no significant differences between two training types. However, they hypothesised that IDT would provide much better results in gait performance. The reason may be, as mentioned above, though CTT trained both cognitive and motor task separately, it can support automaticity of performing of two tasks. So, the improvements of gait can be seen in both single task and dual task conditions and it may be said that to train primary gait and secondary task may be beneficial in terms of developing of the gait performance.

Furthermore, they wanted to investigate whether the gains are transferable to functional performance. Therefore, they assessed the participants in untrained tasks; mobile phone task (Geroin et al, 2018) and stroop task conditions (Strouwen et al., 2017, Geroin et al., 2018) and in contrast to their expectation, similar improvements were found between CTT and IDT groups. The reason of this, again may be that although the interventions were applied separately in CTT, both cognitive task and walking were performed in same manner. Thus, performing the cognitive task may improve and contribute the gait improvements similarly with IDT.

As mentioned above, there are different approach for dual task training and giving instructions is one of them. Fok et al. used instructions during dual task training to PD patients in their both two studies (2010 and 2012). In both two studies, immediate improvement was seen in stride length and gait velocity in dual task condition when the participants took instruction to divided attention into both gait and subtractions (secondary task) equally (Fok et al., 2012), and to focus on taking big steps (Fok et al., 2010). The basis of these improvements may be depended on again the supporting of motor skill learning because the performer engages in taking instructions to figure out what to do and how to do it during the first stage of motor skill learning (Nieuwboer et al., 2009). The benefits were observed also at 30 minutes after- retention period when compared with baseline results but when comparing with post-training results, reduction in gait velocity and stride length was seen. The reason of this may be applying just a single session-30 minutes training program. More training sessions may be more beneficial for continuing the gains in long-term. However, there is a lack of evidence in terms of the effectiveness of dual task gait training with verbal instructions in long-term. Thus, new research may be needed to investigate the effect of more training sessions on gait performance in both two conditions in long-term.

Furthermore, people with PD tend to give priority on secondary cognitive task rather than gait, when they do not take any instructions about focusing on gait (Bloem et al., 2006). This situation can lead to increased dual task interference and so, slower walking and shortened stride length because PD patients' cognitive function and attention are diminished (Canning, 2005, Yogev-Seligman et al., 2005). Therefore, the other reason of the improvements in gait speed and stride length and also reduction of dual task interference in Fok et al.'s (2010) study may be using the gait prioritization during dual task training.

Vanshika and Raja (2012) and Perumal et al. (2017) used similar intervention with Fok et al. (2010 and 2012). They compared the effects of dual task training with fixed priority and dual task training with variable priority instructions on balance performance. Vanshika and Raja (2012) found greater improvement in dual task balance training with variable priority instructions group for BBS score than those in fixed priority group. The reason may be that the necessary task demand is less during the dual task training with variable priority instructions because patients' attention is shifted between two tasks (Kramer et al., 1995).

On the other hand, Perumal et al. (2017) compared the effects of both dual task trainings with single task training and did not found any significant difference between these groups for BBS and DGI scores. The effectiveness of the single task training on balance may be explained with task automatization hypothesis. Performing single tasks may require less processing demand than performing dual tasks. Therefore, skill learning may be faster (Silsupadol et al., 2009). On the other hand, performing dual tasks may require task coordination and this may be provided by practicing of both primary and secondary tasks. Thus, single task training may not be effective always and dual task training may be essential for improving dual task performance (Vanshika and Raja, 2012).

The one aspect of these improvements in Perumal et al.'s (2017) study may relate to included tasks of dual task balance training. Perumal et al. (2017) included some functional tasks, which are parts of the daily life activities such as making a shopping list, carrying a bag, and counting money, as a secondary task. To perform a task repetitively alone may not be enough, and so, the task-specific training may beneficial because it is both meaningful for patients and includes repetition and practice and can lead to changes in cortical level (Hubbard et al., 2009). Therefore, practising such secondary tasks may support improving of both gait and balance performance in people with PD with their task-based nature.

The other type of dual task training was virtual reality (VR) in the two included studies (Mirelman et al., 2011 and Yen et al., 2010). Mirelman et al. (2011) used VR with treadmill gait training. De Sousa et al. (2014) stated that the treadmill training (TT) alone may be beneficial to improve gait during dual task performance in people with PD in their case study. In addition, Mehrolz et al. (2015) showed its benefit on stride length and gait velocity in PD patients in their systematic reviews. On the other hand, VR can support improvements in gait parameters during dual task by providing dual task training because patients have to challenge varying visual task and maintain their walking at the same time. Mirelman et al. (2011) found significant improvements in gait velocity and stride length under dual task condition after 6-weeks TT plus VR training. Similarly, Yen et al. (2010) found improvements in terms of equilibrium score of SOT under both single task and dual task in eyes open on an unstable surface with visual surround condition after VR balance training. All these improvements may be seen thanks to the support of VR on neural organization by providing varying sensory environments and attentional demands (Dunsky et al., 2013).

De Bruin et al. (2010) asked to participants to walk with music. To listen music during the walking lead to cognitive demand as an addition to walking and dual task occurs (Brown et al., 2009). However, De Bruin used the music, which was chosen by participants, and participants did not take any other instructions. The being self-selected of music may ease the giving attention to music during the training. This can lead to also improvements in cognitive function rather than gait performance of patients. It was showed that gait prioritization is beneficial to both improve gait parameters and reduce dual-task interference (Fok et al., 2010). Thus, walking with music may not be efficient method to improve gait parameters. On the other hand, De Bruin et al. (2010) found significant increase in gait speed, cadence and significant decrease in stride time under both single task and dual task conditions after 13-weeks walking with music program. The main reason of these benefits may be rhythmical nature of music. Ghai et al. (2018) stated that rhythmic auditory cues might support the improvements in gait velocity and stride length in people with PD because it can compensate the degenerated rhythm in basal ganglia (Spaulding et al., 2013). On the other hand, the auditory cues provided by a metronome can lead to repetitiveness, and habituation, and so, a reduction in the continuing of its use. Therefore, music can be a good alternative because it is meaningful for patients and they can maintain its use as well as the benefits of rhythmical nature like auditory cues (Brown et al., 2009).

Regarding the balance training in PD patients, two studies used dual task training with balance components without any instructions or other external markers (Fernandes et al., 2015 and Conradsson et al., 2015). While Fernandes et al. (2015) compared the effectiveness of dual task balance training with single task training, the comparison group performed just normal daily activities in Conradsson et al.'s (2015) study. Fernandes et al. (2015) assessed both the static and dynamic balance with TUG and centre of pressure (COT) in PD patients. They found significant differences in both mediolateral and anteroposterior sway in eyes closed position in both groups. The reason of this situation may relate to that PD patients have a flexed posture due to high muscular rigidity and this can lead to postural instability (Jankovic, 2008; Park et al., 2015). However, anteroposterior sway was worse than in dual task training group than those in single task training group. The reason may be the spending time with the disease. Although there were no statistically significant differences between both groups at baseline, the years of disease were more in dual task training group and the flexed posture is observed often late in the disease (Jankovic, 2008).

Conradsson et al. (2015) applied a highly challenging balance program (HiBalance) including dual task with balance components to intervention group. They found significant improvement in MiniBESTest score in training group. These improvements in balance performance in the studies of both Conradsson et al. (2015) and Fernandes et al. (2015) could occur thanks to their intervention approach. Conradsson et al. (2015) gradually integrated the dual tasks into the program. Some studies, which the participants practiced physically perturbed for reaching tasks, showed that individuals taking gradual training demonstrated a slower rate of decay of the adapted reaching pattern, taking longer to re-establish unperturbed reaching movements meaning that these people could adapt to the novel-reaching task. So, gradual training may be effective when the people need to alter what movement strategies are selected to perform the task (Sawers and Hahn, 2013, pg: 606).

Both of the studies progressively increased the difficulty of exercise by increasing the complexity of the cognitive task (Fernandes et al., 2015; Conradsson et al., 2015), variation of exercise, combining balance components (Conradsson et al., 2015). The Challenge Point Framework (CPF) suggests that motor learning may be optimized with manipulation in both nominal task difficulty, which is changes in the just task characteristic, and functional task difficulty, which means challenge of the task by considering the skill level of the person performing the task and the conditions under which it is performed. (Pollock et al., 2014). For example, Orla-or and Winstein (2008) found improved motor learning under low demand practice condition with low nominal task difficulty in PD patients. They also found preserved motor learning under high demand practice condition with both low and high level of task difficulties but in just same contexts with those in training process. Both Conradsson et al. (2015) and Fernandes et al. (2015) changed the functional task difficulty during the training and found improvements in balance performance in PD patients but these studies may not be enough to determine optimal motor learning strategy. Nevertheless, the use of this approach during the dual task balance training in the studies of Fernandes et al. (2015) and Conradsson et al. (2015) may contribute to improvement in balance performance by promoting the motor learning.

Furthermore, although Conradsson et al. (2015) applied balance training, they also assessed the gait parameters; gait velocity, cadence, and step length. They found significant improvement in step length and gait velocity during normal walking after the balance program. Perumal et al. (2017) also, similarly assessed gait performance with DGI and found significant improvements after balance training. These balance training programs surely included some walking activities as well as static balance activities such as walking tasks on varying surfaces with or without visual constraints, walking with a narrow base support, walking backwards. These activities may support the gait performance. In addition, stride length and gait velocity are correlated with dynamic balance in people with early PD (Yang et al., 2008). Therefore, increased balance performance may be related to increased gait velocity in Conradsson et al.'s (2015) study and this kind of balance training may target gait problems as well as balance problem (Conradsson et al., 2015).

In general, it may be said that all these improvements depended on motor learning. Similarly, Conradsson et al. (2015) stated that they applied the intervention according to motor learning principles. The included studies used different tasks for both primary task and secondary task during the dual task trainings, especially balance trainings (Fernandes et al., 2015; Perumal et al., 2017; Conradsson et al., 2015). However, they did not specifically state whether there is a specific order for performing tasks such as random order or blocked order in their intervention. On the other hand, a random practice order may be superior to blocked practice order in providing motor learning because of the higher level of contextual interference induced by random practice order and it requires more cognitive processing (Onla-or and Winstein, 2008). However, as these studies did not state the practice order, it cannot be said that which practice order is better for improving gait and balance performance under different conditions (single task or dual task) in people with PD.

Another factor may relate to the intervention. In each study, different type of dual task training, which can lead to different findings, was used but the other issue was that different intervention duration and intervention frequency were applied. For example, Fok et al. (2010; 2012) applied just one session- dual task gait training with instructions in their both two studies and found improvements in gait parameters. On the other hand, Geroin et al. (2018) and Strouwen et al. (2017) applied dual task gait training twice a week for 6 weeks and found significant improvements in gait velocity under dual task condition and in stride length and cadence under both single and dual task conditions. Surely, the comparison between these studies according to intervention duration and frequency may not be appropriate, when the type of intervention was different. Therefore, to determine an optimal dual task training duration or frequency may be difficult.

Majority of the included studies tried to find the effects of dual task training by comparing different kind of therapy or they compared different types of dual task training. These may contribute to literature so that showing the superiority of dual task training or a type of dual task training over comparison intervention type. However, to determine the exact effect of dual task training on both gait and balance performance in people with PD dual task training group should be compared with a group that gets no interventions. Only two studies (Fok et al. 2010 and Fok et al. 2012) compared the dual task training group with an active control group, who did not get interventions. Thus, they can investigate the effect of the dual task training clearly. On the other hand, during a long study period without any exercise or physical activities can affect people with PD negatively in terms of increasing fall rate or freezing of gait. In this case, during a research, at least to be asked to perform daily life activities may be a sensible approach like those in De Bruin et al.'s (2010) and Conradsson et al.'s (2015) studies. It is thought on Fok et al.'s (2010 and 2012) studies, although their control group did not any intervention, it may be safe for patients because the studies were single session studies.

Another important issue is the adverse events. Mirelman et al. (2010) stated that their all participants completed without any adverse events. Falls are known as a potential safety problem during performing dual tasks. De Bruin et al. (2010) reported the number of falls during the training with music and they did not found safety problem due to the fall because falls occurred when participants performed their daily life activities. In addition, Strouwen et al. (2017) found that fall frequency tended to reduce during the training period. Although these three studies may not be enough to say that the dual task training is safety intervention, it can be said that the dual task training can be applied without facing an adverse event.

Strength and Limitations

Firstly, the eligibility criteria were clearly defined according to the specific research question to reach as much relevant studies as possible, and the number of the included studies was no less. After the quality assessment of the studies, only two studies were found as a weak study, and the marks of other studies varied as moderate to strong and the majority of the studies were strong. As the risk of bias was less in most of the studies, the findings of this systematic review may be reliable and may contribute to the literature. On the other hand, this quality assessment process was conducted by just the author. This may be one of the limitations of this study but to reduce the possible errors, a quality assessment tool (EPHPP) was used.

During the study search, study language did not be limited with English, studies written in Turkish also searched to reach a greater number of relevant studies. However, study selection and data extraction were performed by the author without any other reviewer. This situation can lead to bias but to reduce the errors data extraction was depended on a data extraction form.

In the included studies, the gait or/and balance were assessed. However, in all studies (Vanshika and Raja, 2012 and Perumal et al., 2017 did not state) assessments were applied to participants their ‘ON’ phase, which is the time periods when PD medication is effective and motor function was optimal, within medication cycle. This may ease and suitable period for testing in terms of avoiding the levodopa-induced motor fluctuations. On the other hand, when assessment applied in on phase, a confounder effect of medication may occur on participants’ trial-test performance. Therefore, findings of this systematic review may be trustful in just on medication phase. In addition, the dosage of medication was not stated in the studies. So, its effects are not clear. Therefore, assessments should be applied in both on and off phase.

A limitation of this systematic review related to follow-up results. The included studies investigated the immediate effect of dual task training on gait and balance. Four studies applied 4-weeks or 12-weeks follow-up assessments to participants. In two studies, participants were assessed 30-minutes after training as follow-up. However, these studies may not be enough to show the effect of dual task training in long-term because one of the steps of the motor skill learning refers to retention and retention of skill is less efficient in PD patients compared to age-matched controls (Rochester et al., 2010).

The other issue related to the sample size and participants characteristics of the included studies. The sample sizes of the majority of the studies (except three studies) was relatively small. The small sample size can cause low statistical power and ultimately can cause negative effect to have a statistically significant findings actually reflecting a true effect (Button et al., 2013). This situation also can lead to a limitation for this systematic review in terms of generalization of the findings to PD patients.

In addition, participants' initial condition in terms of both motor capacities and cognitive capacities before the taking intervention can play a crucial role in the response of the interventions. Although practice is the most important element for the permanent improvement in performing a motor skill, a learner's skill level also can significantly affect the proficiency of the motor skill learning (Onla-or and Winstein, 2008). The participants of the included studies had mild to moderate disease severity according to H&Y or Modified H&Y scales and majority of participants had an ability to walk in a certain distance with or without walking aid. Furthermore, the majority of participants in the studies had not cognitive impairment. Thus, their capability was relatively better than PD patients with severe disability and the response to dual task training possibly are different. Therefore, the findings of this systematic review can be generalized and used for PD patients with mild to moderate disease severity.

Furthermore, the participants' year of disease varied 3.8 to 9.8 mean in the included studies that means these participants were not in their early stage of the disease. On the other hand, the effects of intervention in the early stage of the disease may be different. So, this may be an interesting area to investigate the effect of the dual task training in PD patients who are in early stage of the disease.

Conclusion and Recommendation

The included studies in this systematic review had different aims while they were investigating the effectiveness of dual task training such as superiority of dual task training over single task training and conventional training. Also, they used different type of dual task training such as dual task training with different instruction styles (e.g. gait prioritization, fixed priority), virtual reality, and music. As a result, it can be said that there are some strong evidence supporting that dual task training improve gait parameters, especially gait velocity and stride length, under both single and dual task conditions. Fair evidence supports the positive effect of dual task training on improving in balance performance in people with PD.

On the other hand, further studies, which have larger sample size and application of assessments in not only on-medication phase but also off-medication phase, may be needed. In addition, as majority of the included studies did not apply follow-up assessment, further studies are needed to investigate the long-term effect of dual task training on gait and balance in people with PD.

For the clinical use of dual task training, it can be safe. It can be used with different approaches like instructions or music, and different training duration and frequency. Although this situation cannot allow to establish a standard dual task training protocol, it can be tailored easily according to patients' initial capacity and preferences.

Conflicts of Interest

The author of this research paper undertook the project as part of an MSc programme. There are no conflicts of interests to declare and no sources of funding to declare.

References

Abbas, Z., Raza, S. and Ejaz, K. (2008) ‘Systematic reviews and their role in evidence-informed health care.’, *Journal of the Pakistan Medical Association*, 58(10), pp. 561–567.

Abbruzzese, G. *et al.* (2016) ‘Parkinsonism and Related Disorders Rehabilitation for Parkinson ’ s disease : Current outlook and future challenges’. Elsevier Ltd, 22, pp. 60–64. doi: 10.1016/j.parkreldis.2015.09.005.

Agoritsas, T., Merglen, A., Courvoisier, D., Combescure, C., Garin, N., Perrier, A. and Perneger, T. (2012). Sensitivity and Predictive Value of 15 PubMed Search Strategies to Answer Clinical Questions Rated Against Full Systematic Reviews. Journal of Medical Internet Research, 14(3), p.e85.

An, H.-J. *et al.* (2014) ‘The Effect of Various Dual Task Training Methods with Gait on the Balance and Gait of Patients with Chronic Stroke’, *Journal of Physical Therapy Science*, 26(8), pp. 1287–1291. doi: 10.1589/jpts.26.1287.

Armijo-olivo, S. *et al.* (2012) ‘Assessment of study quality for systematic reviews : a comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool : methodological research’, 18, pp. 12–18. doi: 10.1111/j.1365-2753.2010.01516.x.

Barbosa, A. F. *et al.* (2016) ‘Gait , posture and cognition in Parkinson ’ s disease’, 10(4), pp. 280–286. doi: 10.1590/S1980-5764-2016DN1004005.

Bloem, B. R. *et al.* (2006) ‘The “‘ posture second ’” strategy : A review of wrong priorities in Parkinson ’ s disease’, 248, pp. 196–204. doi: 10.1016/j.jns.2006.05.010.

Borrione, P., Tranchita, E. and Sansone, P. (2014) ‘tool for rehabilitation’, 4(3), pp. 133–144. doi: 10.5662/wjm.v4.i3.133.

Barton, S. (2000). Which clinical studies provide the best evidence?. BMJ, 321(7256), pp.255-256.

Braak, H. *et al.* (2003) 'Staging of brain pathology related to sporadic Parkinson ' s disease', 24, pp. 197–211.

Brauer, S. G. *et al.* (2011) 'Single and dual task gait training in people with Parkinson's Disease: A protocol for a randomised controlled trial', *BMC Neurology*. doi: 10.1186/1471-2377-11-90.

Brown, L. A. *et al.* (2009) 'Novel Challenges to Gait in Parkinson ' s Disease : The Effect of Concurrent Music in Single- and Dual-Task Contexts', *YAPMR*. Elsevier Inc., 90(9), pp. 1578–1583. doi: 10.1016/j.apmr.2009.03.009.

Bruin, N. De *et al.* (2010) 'Walking with Music Is a Safe and Viable Tool for Gait Training in Parkinson ' s Disease : The Effect of a 13-Week Feasibility Study on Single and Dual Task Walking', 2010. doi: 10.4061/2010/483530.

Burns, P., Rohrich, R. and Chong, K. (2011) 'The Levels of Evidence and their role in Evidence-Based Medicine', *Plast Reconstr Surg*, 128(1), pp. 305–310. doi: 10.1097/PRS.0b013e318219c171.The.

Button, K. S. *et al.* (2013) 'Power failure: why small sample size undermines the reliability of neuroscience'. Nature Publishing Group, 14(May). doi: 10.1038/nrn3475.

Cakit, B. D. *et al.* (2007) 'The effects of incremental speed-dependent treadmill training on postural instability and fear of falling in Parkinson ' s disease', pp. 698–705.

Canning, C. G. (2005) 'The effect of directing attention during walking under dual-task conditions in Parkinson ' s disease', 11, pp. 95–99. doi: 10.1016/j.parkreldis.2004.09.006.

Carpinella, I. *et al.* (2017) 'Wearable Sensor-Based Biofeedback Training for Balance and Gait in Parkinson Disease: A Pilot Randomized Controlled Trial', *Archives of Physical Medicine and Rehabilitation*. Elsevier Inc, 98(4), p. 622–630.e3. doi: 10.1016/j.apmr.2016.11.003.

Christofoletti, G. *et al.* (2016) 'Investigation of factors impacting mobility and gait in Parkinson disease', *Human Movement Science*. Elsevier B.V., 49, pp. 308–314. doi: 10.1016/j.humov.2016.08.007.

Clarke, J. (2011). What is a systematic review?. Evidence-Based Nursing, 14(3), pp.64-64.

Conradsson, D. *et al.* (2015) 'The Effects of Highly Challenging Balance Training in Elderly With Parkinson ' s Disease : A Randomized Controlled Trial'. doi: 10.1177/1545968314567150.

Da Costa, B. R. and Jüni, P. (2014) 'Systematic reviews and meta-analyses of randomized trials: Principles and pitfalls', *European Heart Journal*, pp. 3336–3345. doi: 10.1093/eurheartj/ehu424.

CRD (2009) 'Systematic Reviews: CRD's guidance for undertaking reviews in health care'. [Online]. Available at: https://www.york.ac.uk/media/crd/Systematic_Reviews.pdf.

Curtze, C. *et al.* (2018) 'Objective Gait and Balance Impairments Relate to Balance People With Parkinson Disease', 96(11).

Darweesh, S. K. L. *et al.* (2016) 'Trends in the Incidence of Parkinson Disease in the General Population', *American Journal of Epidemiology*, 183(11), pp. 1018–1026. doi: 10.1093/aje/kwv271.

Dunsky, A., Fishbein, P. and Hutzler, Y. (2013) 'Dual-task training using virtual reality : Influence on walking and balance in three post stroke survivors', (December 2016). doi: 10.5455/ijtrr.00000021.

Earhart, G. M. and Williams, A. J. (2012) 'Treadmill Training for Individuals With Parkinson Disease', *Physical Therapy*. doi: 10.2522/ptj.20110471.

Elbaz, A., Carcaillon, L., Kab, S. and Moisan, F. (2016). Epidemiology of Parkinson's disease. Revue Neurologique, 172(1), pp.14-26.

Evans, D. (2003) 'Hierarchy of evidence: A framework for ranking evidence evaluating healthcare interventions', *Journal of Clinical Nursing*, 12(1), pp. 77–84. doi: 10.1046/j.1365-2702.2003.00662.x.

Fernandes, Â. *et al.* (2015) 'Effects of dual-task training on balance and executive functions in Parkinson's disease: A pilot study', *Somatosensory & Motor Research*, 32(2), pp. 122–127. doi: 10.3109/08990220.2014.1002605.

Fok, P., Farrell, M. and Mcmeeken, J. (2012) ‘Human Movement Science The effect of dividing attention between walking and auxiliary tasks in people with Parkinson ’ s disease’, *Human Movement Science*. Elsevier B.V., 31(1), pp. 236–246. doi: 10.1016/j.humov.2011.05.002.

Fok, P., Farrell, M. and McMeeken, J. (2010) ‘Prioritizing gait in dual-task conditions in people with Parkinson’s’, *Human Movement Science*. Elsevier B.V., 29(5), pp. 831–842. doi: 10.1016/j.humov.2010.06.005.

Fritz, N. E., Cheek, F. M. and Nichols-Larsen, D. S. (2015) ‘Motor-Cognitive Dual-Task Training in Persons With Neurologic Disorders’, *Journal of Neurologic Physical Therapy*. doi: 10.1097/NPT.0000000000000090.

Geroin, C. *et al.* (2018) ‘Parkinsonism and Related Disorders Does dual-task training improve spatiotemporal gait parameters in Parkinson ’ s disease ?’, *Parkinsonism and Related Disorders*. Elsevier, (April), pp. 0–1. doi: 10.1016/j.parkreldis.2018.05.018.

Ghai, S. *et al.* (2018) ‘Effect of rhythmic auditory cueing on parkinsonian gait: A systematic review and meta-analysis’, *Scientific Reports*, 8(1), pp. 1–19. doi: 10.1038/s41598-017-16232-5.

ten Ham-Baloyi, W. and Jordan, P. (2016) ‘Systematic review as a research method in post-graduate nursing education’, *Health SA Gesondheid*. Elsevier Ltd, 21(0), pp. 120–128. doi: 10.1016/j.hsag.2015.08.002.

Hamani, C. and Lozano, A. (2003). Physiology and Pathophysiology of Parkinson's Disease. Annals of the New York Academy of Sciences, 991(1), pp.15-21.

Harrison, J. *et al.* (2017) ‘Using quality assessment tools to critically appraise ageing research: a guide for clinicians’, *Age and Ageing*, 46(December 2016), pp. 359–365. doi: 10.1093/ageing/afw223.

Hass, C. J. *et al.* (2012) ‘Gait & Posture Progressive resistance training improves gait initiation in individuals with Parkinson ’ s disease’, *Gait & Posture*. Elsevier B.V., 35(4), pp. 669–673. doi: 10.1016/j.gaitpost.2011.12.022.

Holmes, J. D. *et al.* (2010) ‘Dual-Task Interference : The Effects of Verbal Cognitive Tasks on Upright Postural Stability in Parkinson ’ s Disease’, 2010. doi:

10.4061/2010/696492.

Hubbard, I. J. *et al.* (2009) 'Task-specifi c training : evidence for and translation to clinical practice', 16(June), pp. 175–189. doi: 10.1002/oti.

Jankovic, J. (2008) 'Parkinson ' s disease : clinical features and diagnosis', (1957), pp. 368–376. doi: 10.1136/jnnp.2007.131045.

Jüni, P., Altman, D. G. and Egger, M. (2001) 'Assessing the quality of controlled clinical trials', 323(July), pp. 42–46.

Kelly, V. E., Eusterbrock, A. J. and Shumway-cook, A. (2012) 'The Effects of Instructions on Dual-Task Walking and Cognitive Task Performance in People with Parkinson ' s Disease', 2012. doi: 10.1155/2012/671261.

Kramer, A. F., Larish, J. F. and Strayer, D. L. (1995) 'Training for Attentional Control in Dual Task Settings : A Comparison of Young and Old Adults', 1(1), pp. 50–76.

Leavy, B. *et al.* (2018) 'Research Report Original Research', 97(1).

Martinez-Martin, P. *et al.* (2015) 'Assessing the non-motor symptoms of Parkinson's disease: MDS-UPDRS and NMS Scale', *European Journal of Neurology*, 22(1), pp. 37–43. doi: 10.1111/ene.12165.

McCrae, N. and Purssell, E. (2015) 'Eligibility criteria in systematic reviews published in prominent medical journals: A methodological review', *Journal of Evaluation in Clinical Practice*, 21(6), pp. 1052–1058. doi: 10.1111/jep.12448.

Mehrholz, J. *et al.* (2010) 'Treadmill training for patients with Parkinson ' s disease (Review)', (1).

Mehrholz, J. *et al.* (2015) 'Treadmill training for patients with Parkinson ' s disease (Review)', (9). doi: 10.1002/14651858.CD007830.pub4.www.cochranelibrary.com.

Melnyk, B., Fineout-Overholt, E., Stillwell, S. and Williamson, K. (2010). Evidence-Based Practice: Step by Step: The Seven Steps of Evidence-Based Practice. AJN, American Journal of Nursing, 110(1), pp.51-53.

Mirelman, A. *et al.* (2018) 'Virtual Reality for Gait Training : Can It Induce Motor Learning to Enhance Complex Walking and Reduce Fall Risk in Patients With Parkinson ' s Disease ?', (July), pp. 234–240. doi: 10.1093/gerona/glq201.

Moher, D. *et al.* (2007) 'REVIEW ARTICLE A systematic review identified few methods and strategies describing when and how to update systematic reviews', 60. doi: 10.1016/j.jclinepi.2007.03.008.

Nieuwboer, A., Rochester, L. and Liesbeth, M. (2009) 'Parkinsonism and Related Disorders Motor learning in Parkinson ' s disease : limitations and potential for rehabilitation', 3, pp. 53–58. doi: 10.1016/S1353-8020(09)70781-3.

Normann, B. *et al.* (2012) 'Patient satisfaction and perception of change following single physiotherapy consultations in a hospital ' s outpatient clinic for people with multiple sclerosis Patient satisfaction and perception of change following single physiotherapy consultations in', 3985. doi: 10.3109/09593985.2011.574782.

Onla-or, S. and Winstein, C. J. (2008) 'Determining the Optimal Challenge Point for Motor Skill Learning in Adults With Moderately Severe Parkinson's Disease', pp. 7–12. doi: 10.1177/1545968307313508.

Park, J., Kang, Y. and Horak, F. B. (2015) 'What Is Wrong with Balance in Parkinson ' s Disease ?', 8(3), pp. 109–114.

Perumal, V. *et al.* (2017) 'Instruction prioritization in task-based balance training for individuals with idiopathic Parkinson ' s disease', 0220. doi: 10.1080/08990220.2016.1278203.

Petzinger, G., Fisher, B., McEwen, S., Beeler, S., Walsh, J., Jakowec, M. E. N. T. (2013) 'Cognitive Circuitry in Parkinson's Disease', *Lancet Neurol*, 12(7), pp. 716–726. doi: 10.1016/S1474-4422(13)70123-6.Exercise-enhanced.

Picelli, A. *et al.* (2012) 'Robot-Assisted Gait Training in Patients With Parkinson Disease : A Randomized Controlled Trial'. doi: 10.1177/1545968311424417.

Pollock, C. L. *et al.* (2018) 'Case Report to Guide Motor Learning of Stepping Reactions for Improved Balance Control in People With Stroke : A Case Series', 94(4).

Rochester, L., Baker, K., *et al.* (2010) 'Evidence for motor learning in Parkinson ' s disease : Acquisition , automaticity and retention of cued gait performance after training with external rhythmical cues', *Brain Research*. Elsevier B.V., 1319, pp. 103–111. doi: 10.1016/j.brainres.2010.01.001.

Rochester, L., Rafferty, D., *et al.* (2010) ‘The effect of cueing therapy on single and dual-task gait in a drug naïve population of people with parkinson’s disease in Northern Tanzania’, *Movement Disorders*, 25(7), pp. 906–911. doi: 10.1002/mds.22978.

Rochester, L. *et al.* (2014) ‘THE NATURE OF DUAL-TASK INTERFERENCE DURING GAIT IN INCIDENT PARKINSON ’ S DISEASE’, *NEUROSCIENCE*. IBRO, 265, pp. 83–94. doi: 10.1016/j.neuroscience.2014.01.041.

Ruthruff, E., Ames, N. and Field, M. (2003) ‘Dual-task interference with equal task emphasis : Graded capacity sharing or central postponement ?’, 65(5), pp. 801–816.

Santos, L. A. A. *et al.* (2016) ‘Effects of dual-task interventions on gait performance of patients with Parkinson’s Disease: A systematic review’, *Medical Express*, 3(4), pp. 1–10. doi: 10.5935/MedicalExpress.2016.04.01.

Sawers, A. and Hahn, M. E. (2013) ‘Human Movement Science Gradual training reduces practice difficulty while preserving motor learning of a novel locomotor task’, *HUMAN MOVEMENT SCIENCE*. Elsevier B.V., 32(4), pp. 605–617. doi: 10.1016/j.humov.2013.02.004.

Silsupadol, P. *et al.* (2009) ‘Effect of single-task versus dual-task training on balance performance in older adults: a double-blind, randomized controlled trial’, *Archives of Physical Medicine and Rehabilitation*, 90(3), pp. 381–387. doi: 10.1016/j.apmr.2008.09.559.Effects.

Spaulding, S. J. *et al.* (2013) ‘Cueing and Gait Improvement Among People With Parkinson ’ s Disease : A Meta-Analysis’, *Archives of Physical Medicine and Rehabilitation*. Elsevier Ltd, 94(3), pp. 562–570. doi: 10.1016/j.apmr.2012.10.026.

Strouwen, C. *et al.* (2014) ‘Protocol for a randomized comparison of integrated versus consecutive dual task practice in Parkinson’s disease: the DUALITY trial’, *BMC Neurology*. doi: 10.1186/1471-2377-14-61.

Strouwen, C. *et al.* (2017) ‘Training dual tasks together or apart in Parkinson’s disease: Results from the DUALITY trial’, *Movement Disorders*, 32(8), pp. 1201–1210. doi: 10.1002/mds.27014.

Sveinbjornsdottir, S. (2016) ‘The clinical symptoms of Parkinson’s disease’, *Journal* *of Neurochemistry*, pp. 318–324. doi: 10.1111/jnc.13691.

Vanshika, R. R. (2012) ‘Effects of dual task training on balance and activities of daily livings (adls)’, 3(1), pp. 1359–1364. Available at: http://www.biomedscidirect.com/470/effects_of_dual_task_training_on_balance_and_activities_of_daily_livings_adls/articlescategories.

Varalta, V. *et al.* (2015) ‘Relationship between cognitive performance and motor dysfunction in patients with Parkinson’s disease: A pilot cross-sectional study’, *BioMed Research International*. doi: 10.1155/2015/365959.

Vergnes, J. N. *et al.* (2010) ‘Ethics in systematic reviews’, *Journal of Medical Ethics*, 36(12), pp. 771–774. doi: 10.1136/jme.2010.039941.

Vieira, A. *et al.* (2014) ‘Influence of treadmill training in dual-task gait in people with Parkinson ’ s Disease : a case report’, (July), pp. 291–296. doi: 10.590/1809-2950/60221032014.

Wood, L. *et al.* (2008) ‘Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: Meta-epidemiological study’, *BMJ*, 336(7644), pp. 601–605. doi: 10.1136/bmj.39465.451748.AD.

Wu, T. and Hallett, M. (2008) ‘Neural correlates of dual task performance in patients with Parkinson ’ s disease’, pp. 760–766. doi: 10.1136/jnnp.2007.126599.

Yang, Y. *et al.* (2008) ‘Relationships between gait and dynamic balance in early Parkinson ’ s disease’, 27, pp. 611–615. doi: 10.1016/j.gaitpost.2007.08.003.

Yen, C. *et al.* (2011) ‘Effects of Virtual Reality–Augmented Balance Training on Sensory Organization and Attentional Demand for Postural Control in People With Parkinson Disease: A Randomized Controlled Trial’, *Physical Therapy*, 91(6), pp. 862–874. doi: 10.2522/ptj.20100050.

Yogev-Seligmann, G. *et al.* (2012) ‘A training program to improve gait while dual tasking in patients with Parkinson’s disease: A pilot study’, *Archives of Physical Medicine and Rehabilitation*. Elsevier Inc., 93(1), pp. 176–181. doi: 10.1016/j.apmr.2011.06.005.

Yogev, G. *et al.* (2005) ‘Dual tasking , gait rhythmicity , and Parkinson ’ s disease : Which aspects of gait are attention demanding ?’, 22(June), pp. 1248–1256. doi:

10.1111/j.1460-9568.2005.04298.x.

Appendix

Appendix 1: PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	

FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

Appendix 2: JBI Data Extraction Form

JBI Data Extraction Form for
Experimental / Observational Studies

Reviewer _______________ Date _______________

Author _______________ Year _______________

Journal _______________ Record Number _______________

Study Method

RCT	☐	Quasi-RCT	☐	Longitudinal	☐
Retrospective	☐	Observational	☐	Other	☐

Participants

Setting _______________

Population _______________

Sample size

Group A _______________ Group B _______________

Interventions

Intervention A _______________

Intervention B _______________

Authors Conclusions: _______________

Reviewers Conclusions: _______________

Appendix 3: EPHPP Quality Assessment Tool

QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES

EPHPP
Effective Public Health Practice Project

COMPONENT RATINGS

A) SELECTION BIAS

(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?

1 Very likely
2 Somewhat likely
3 Not likely
4 Can't tell

(Q2) What percentage of selected individuals agreed to participate?

1 80 - 100% agreement
2 60 – 79% agreement
3 less than 60% agreement
4 Not applicable
5 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

B) STUDY DESIGN

Indicate the study design

1 Randomized controlled trial
2 Controlled clinical trial
3 Cohort analytic (two group pre + post)
4 Case-control
5 Cohort (one group pre + post (before and after))
6 Interrupted time series
7 Other specify __________________________
8 Can't tell

Was the study described as randomized? If NO, go to Component C.

No Yes

If Yes, was the method of randomization described? (See dictionary)

No Yes

If Yes, was the method appropriate? (See dictionary)

No Yes

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

C) CONFOUNDERS

(Q1) **Were there important differences between groups prior to the intervention?**
1 Yes
2 No
3 Can't tell

The following are examples of confounders:
1 Race
2 Sex
3 Marital status/family
4 Age
5 SES (income or class)
6 Education
7 Health status
8 Pre-intervention score on outcome measure

(Q2) **If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?**
1 80 – 100% (most)
2 60 – 79% (some)
3 Less than 60% (few or none)
4 Can't Tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

D) BLINDING

(Q1) **Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?**
1 Yes
2 No
3 Can't tell

(Q2) **Were the study participants aware of the research question?**
1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

E) DATA COLLECTION METHODS

(Q1) **Were data collection tools shown to be valid?**
1 Yes
2 No
3 Can't tell

(Q2) **Were data collection tools shown to be reliable?**
1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

F) WITHDRAWALS AND DROP-OUTS

(Q1) **Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?**
1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

(Q2) **Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).**
1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) INTERVENTION INTEGRITY

(Q1) **What percentage of participants received the allocated intervention or exposure of interest?**
1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

(Q2) **Was the consistency of the intervention measured?**
1 Yes
2 No
3 Can't tell

(Q3) **Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?**
4 Yes
5 No
6 Can't tell

H) ANALYSES

(Q1) **Indicate the unit of allocation (circle one)**
community organization/institution practice/office individual

(Q2) **Indicate the unit of analysis (circle one)**
community organization/institution practice/office individual

(Q3) **Are the statistical methods appropriate for the study design?**
1 Yes
2 No
3 Can't tell

(Q4) **Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?**
1 Yes
2 No
3 Can't tell

F) **WITHDRAWALS AND DROP-OUTS**

(Q1) **Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?**
1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

(Q2) **Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).**
1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) **INTERVENTION INTEGRITY**

(Q1) **What percentage of participants received the allocated intervention or exposure of interest?**
1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

(Q2) **Was the consistency of the intervention measured?**
1 Yes
2 No
3 Can't tell

(Q3) **Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?**
4 Yes
5 No
6 Can't tell

H) **ANALYSES**

(Q1) **Indicate the unit of allocation (circle one)**
community organization/institution practice/office individual

(Q2) **Indicate the unit of analysis (circle one)**
community organization/institution practice/office individual

(Q3) **Are the statistical methods appropriate for the study design?**
1 Yes
2 No
3 Can't tell

(Q4) **Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?**
1 Yes
2 No
3 Can't tell

GLOBAL RATING

COMPONENT RATINGS

Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

A	**SELECTION BIAS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
B	**STUDY DESIGN**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
C	**CONFOUNDERS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
D	**BLINDING**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
E	**DATA COLLECTION METHOD**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
F	**WITHDRAWALS AND DROPOUTS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	Not Applicable

GLOBAL RATING FOR THIS PAPER (circle one):

1 STRONG (no WEAK ratings)
2 MODERATE (one WEAK rating)
3 WEAK (two or more WEAK ratings)

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-F) ratings?

No Yes

If yes, indicate the reason for the discrepancy

1 Oversight
2 Differences in interpretation of criteria
3 Differences in interpretation of study

Final decision of both reviewers (circle one):

1 STRONG
2 MODERATE
3 WEAK