

# The effect of exercise interventions on the balance of diabetic neuropathic patients: A systematic review study

Fatemeh Ebrahimi Meymand<sup>1</sup>, Mahdieh Akoochakian<sup>1\*</sup>, Mansour Sahebozamani<sup>2</sup>

1. Department of Sports Sciences, Kish International Campus, University of Tehran, Kish, Iran. (\*Corresponding author, Email: makoochakian@ut.ac.ir)
2. Department of Sports Injuries and Corrective Exercises, Faculty of Sport Science, Shahid Bahonar University of Kerman, Kerman, Iran.

Article Info	Abstract
<p>Original Article</p> <p><b>Article history:</b></p> <p>Received: 10 July 2020</p> <p>Revised: 10 August 2020</p> <p>Accepted: 1 October 2020</p> <p>Published online: 1 January 2021</p> <p><b>Keywords:</b> balance, diabetic neuropathy, physical activity.</p>	<p><b>Background:</b> Diabetic peripheral neuropathy (DPN) reduces the senses, proprioception, reflexes, and strength in the lower extremities and leads to balance dysfunction.</p> <p><b>Aim:</b> This study aimed to evaluate the effectiveness of interventions used by researchers and therapists to minimize balance dysfunction in people with DPN.</p> <p><b>Materials and Methods:</b> This study is a comprehensive review of exercise interventions on the balance of patients with diabetic neuropathy by searching in the PubMed Elsevier, Springer, Science Direct, Google Scholar, and Scopus databases with the combined keywords “balance”, “diabetic peripheral neuropathy”, “training interventions”, “proprioception”, “risk of diabetic fall”, “peripheral neuropathy” and also in Persian databases of Jihad Daneshgahi Scientific Information Center, MedLib (Comprehensive Database of Medical Articles), IranMedex, Iran Institute of Information Science and Technology Research Institute (IRANDOC), Iranian Publications Database (MAGIRAN) and with keywords “fall risk”, “profundity” and “postural control in diabetic neuropathic patients” from 2010 to 2021. After collecting the search results, first the title and then the summary of the pieces were studied. If the articles met the inclusion and exclusion criteria, their results would be used in the review study and otherwise discarded.</p> <p><b>Results:</b> Twenty-five studies published between 2010 and 2021 met the inclusion criteria. The results showed that training interventions were more effective than control conditions to improve the balance of patients with diabetic neuropathy. Also, the most training programs and rehabilitation protocols have a positive effect on the balance of patients with diabetic neuropathy.</p> <p><b>Conclusion:</b> The studied exercise interventions are an effective tool to improve the balance of diabetic neuropathy patients. However, given the small number of studies and their limitations, the present findings of this study should be considered.</p>

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## 1. Introduction

Diabetic Peripheral Neuropathy (DPN) is a severe complication of type 1 and type 2 diabetes, one of the most common microvascular complications among patients with T2DM. Approximately 49.3% of patients with type 2 diabetes in Iran have diabetic neuropathy [1]. DPN is heterogeneous and affects different parts of the nervous system, resulting in symptoms depending on the location and type of nerve fibers involved. The most common symptoms of DPN are numbness, tingling, and pain that may worsen during the night. Nocturnal cramps and instability in walking from the toes to the soles of the feet, ankles, and legs also begin [2].

Researchers have reported that diabetic neuropathy causes a severe functional imbalance in patients with diabetes. Impaired foot sensation, proprioception, biomechanical structures, and misunderstanding of joint position have been reported as causes of inequality in these individuals, resulting in postural instability and decreased balance in chronic neuropathic individuals and the production of ataxia or symptoms. It becomes a Rumberg. A balance disorder is seen in 16% of diabetics [3], increasing disease severity by 30 to 50% [4]. It has also been reported that these people are 15 times more likely to fall than healthy people and patients without neuropathy [5, 6], which shows that loss of balance is one of the critical complications of this disease [7]. Therefore, the issue of imbalance is one of the most essential issues related to people with DPN reflexes, coordination, and gait control [8]. These factors limit the risk of walking and other activities and increase the risk of falling [9]. Unfortunately, these side effects make DPN people less interested in participating in exercise

programs. Due to these complications and prevalence, treatment and rehabilitation measures are necessary for these people.

Physical exercise can improve the balance indicators of people with diabetes and DPN. Although researchers and health professionals can play an essential role in managing balance dysfunction as a result of DPN, no comprehensive study has been published on this subject. Therefore, the purpose of this study is to systematically review the studies performed to determine the effectiveness of different training interventions on balance dysfunction in people with DPN. This study has been conducted for systematic review.

## 2. Materials and Methods

This study is a comprehensive review of exercise interventions on the balance of patients with diabetic neuropathy by searching in the PubMed Elsevier, Springer, Science Direct, Google Scholar, and Scopus databases with the combined keywords “balance”, “diabetic peripheral neuropathy”, “training interventions”, “proprioception”, “risk of diabetic fall”, “peripheral neuropathy” and also in Persian databases of Jihad Daneshgahi Scientific Information Center, MedLib (Comprehensive Database of Medical Articles), IranMedex, Iran Institute of Information Science and Technology Research Institute (IRANDOC), Iranian Publications Database (MAGIRAN) and with keywords “fall risk”, “profundity” and “postural control in diabetic neuropathic patients” from 2010 to 2021.

In addition, the sources of the retrieved studies were analyzed to identify other relevant publications. PRISMA guidelines (preferential reporting cases for systematic analysis and meta-analysis) were followed to evaluate the literature results. The

researchers analyzed the titles and abstracts during the study selection process when the title and abstract contained sufficient information to decide on the review study results. If the articles did not meet the inclusion criteria, they were excluded from the review study.

The inclusion criteria for including the articles in this study were: (1) research in which to examine different types of exercise on balance and related factors, including proprioception, fall risk, etc., (2) being on individuals who have DPN, (3) studies which conducted in the last 11 years. If a study did not meet one of the inclusion criteria, it would be excluded from the present review.

Exclusion criteria in this study include: (1) case reports, (2) irrelevant articles, (3) articles with only a summary of them, (4) articles that only covered the DPN incidence, and (5) articles published in conferences.

The evaluation form was used to collect the main features of each article and extract the desired data, which included the following data: (1) names of authors and year of publication, (2) type of study performed, (3) average age of subjects and study groups, (4) type of training program, (5) duration of the training program, and (6) findings of the study.

### 2.1. Selection of research

In the first stage, screening of the title and abstract of descriptive studies focusing on balance in diabetic neuropathic patients and publication in Persian and English were performed. The two research authors independently reviewed abstracts of articles. The second step was to screen the entire text according to the published articles (effect of exercise interventions on the balance of neuropathic diabetics) and

the specificity of the target population (Figure 1).

### 3. Result

After reviewing the selected articles in the present study, approximately 872 people were present in the study groups (control group and intervention group). The number of participants in each study ranged from 8 to 73. The average age of the participants was 40 to 79 years. Also, in this study to evaluate the static and dynamic balance, Biodex stability system tests (8 studies, 32%), BERG balance scale (9 studies, 36%), Time Up and Go test (TUG) (8 studies, 32%), standing on a Foot (7 studies, 28%), functional test (2 studies, 8%), five sitting and standing tests (2 studies, 8%), and Sharpen Romberg test, walking on a balance stick, 10 minutes walking, sliding board, Wobbleboard of walking ability and reaction time, star test, Fukuda test, and international risk of fall scale (1 study 4%) were performed.

In this study, intervention training programs of balance (8 studies, 32%), strength-balance (5 studies, 20%), deep sense and massage (5 studies, 20%), and combined (6 studies, 24%) were used. The duration of the training interventions was from 2 to 12 weeks, and the training sessions were held 1 to 3 sessions per week and lasted for 15 seconds to 65 min/day. Findings were reported in Table 1.

#### 3.1. Balance exercises on balance of people with diabetic neuropathy

Table 1 shows that eight studies have examined the effect of balance exercises on balance and postural control of people with DPN. Song et al. (2011) studied the development of balance exercises on the proprioception of people with DPN with an average age of 73 years for eight weeks.

The results showed that balance in all

tests (Berg balance scale, time up and go test, and walking for 10 min) was created in the intervention group [10]. Akbari et al. (2012) [11], and Eftekhar et al. (2015) [12] also studied the effect of these exercises on people with DPN. These researchers showed the influence of balance exercises on improving stability and postural stability in people with DPN. On the other hand, Khushnood et al. (2019) examined the effect of Wii FIT balance exercises. Eight-week exercises were performed 30 min each time and twice a week. The results showed a significant difference between the two exercises in improving balance [13]. Also, Akbari et al. (2011) examined people with an average age of 69-69 years. The

results showed that balance training for four sessions improves balance [14]. Salsabil et al. (2011) [15] and Grewal et al. (2021) [16] evaluated people with an average age of 56 and 62 years in 3 and 4 weeks, respectively. These two studies showed that balance exercises improve postural control in the standing position and increase balance. In a study of 38 people, Daud et al. (2021) performed balance exercises for six weeks. The results showed that balance with Biodex increased functional balance in these individuals. Hence, systematic studies suggest that balance exercise interventions can increase physical function and balance, and can reduce fall risk in different populations with DPN [17].

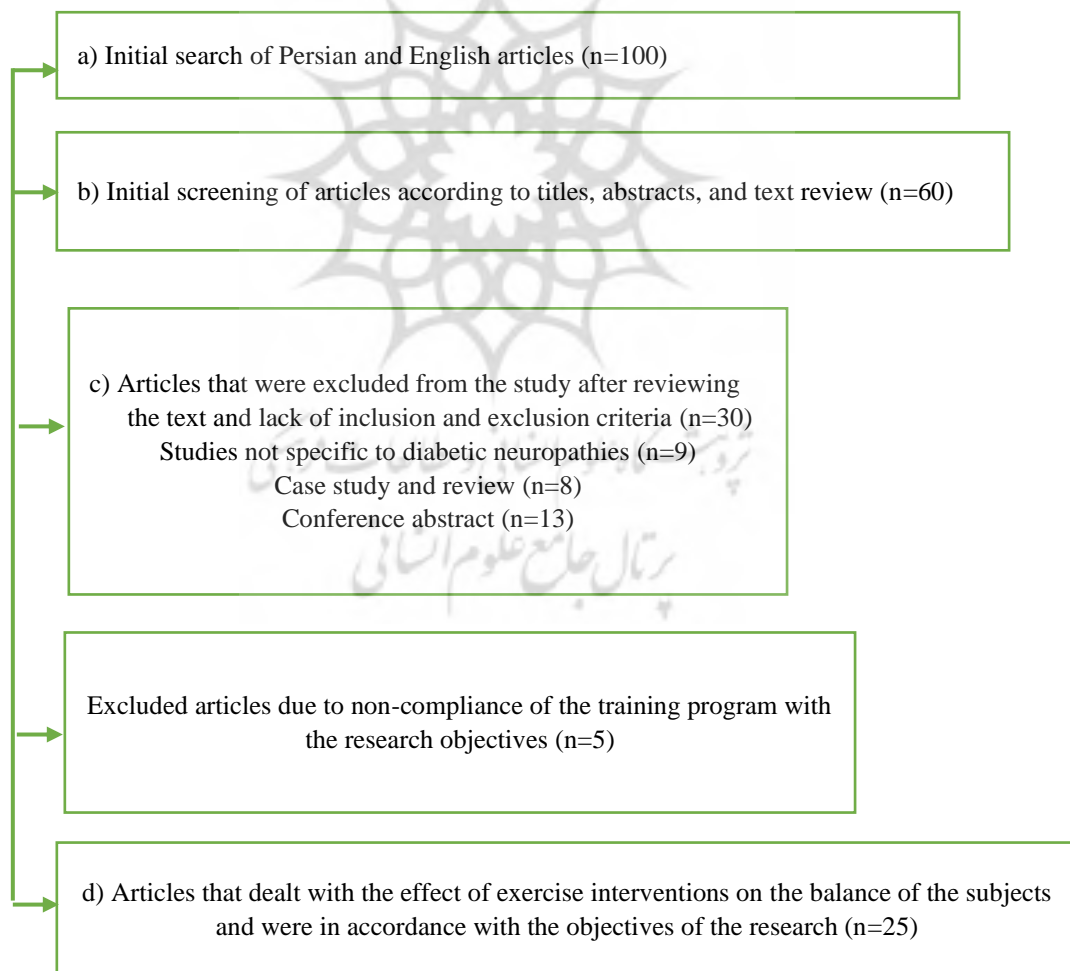


Figure 1. The process of selecting research articles

**Table 1.** Intervention training programs of balance, strength-balance, deep sense and massage, and combined in 2-12 weeks, 1-3 sessions per week, and lasted for 15 sec to 65 min/day

Output result	Practical intervention (duration/ time/ repeat)	How to diagnose	Type of exercise program	Objective evaluation (Assessment tool)	Sample and age (Average age)	
In people with diabetic neuropathy, exercise improves balance, gait, and muscle strength	12 weeks/ NA/ 2 times a week	Vibration perception threshold $\leq 4$	Balance and strength training	Time to walk Over a beam biodex	n=36 control group Average age: 64 year n=35 intervention group Average age: 63 years	Allet et al. (2010) [18]
Balance and strength training of the lower extremity muscles positively affected the balance of people with neuropathy. These exercises did not involve improving the risk of falls.	12 weeks/ NA/ 2 times a week	Physician's diagnosis	Lower body strength training and balance training	Berg balance scale TUG	n=38 control group Average age: 64.8 years n=41 intervention group Average age: 66.3 years	Kruse et al. (2010) [19]
Balance exercises improve balance and increase torso proprioception	8 weeks/ 60 min/ 2 times a week	Physician's diagnosis	Balance training	10 min of walk Berg balance scale TUG	n=19 control group Average age: 72.9 years n=19 intervention group Average age: 73.2 years	Song et al. (2011) [10]
Balance exercises and external visual feedback improve postural control in the standing position and increase balance.	3 weeks/ 30 min/ 10 sessions	Valk polyneuropathy score Snellen table	Dynamic stability exercises	Biodex	n=19 intervention group Average age: 56 years	Salsabil et al. (2011) [15]
Balance exercises can improve stability indicators in people with diabetic neuropathy.	NA/ 15 sec/ 5 times	Electrodiagnostic tests	Balance training	Wobble board Biodex	n=10 control group Average age: 56.2 years n=10 intervention group Average age: 55.8 years	Akbari et al. (2012) [11]
Tai Chi exercise improves blood glucose levels, increases balance, and improves the symptoms of neuropathy.	12 weeks/ 1 hour/ 2 times a week	Monofilament examination total score of neuropathic symptoms	Taichi exercise	Stand on one foot with closed eyes	n=19 control group Average age: 62.7 years n=20 intervention group Average age: 66.05 years	Ahn et al. (2012) [33]

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Output result	Practical intervention (duration/ time/ repeat)	How to diagnose	Type of exercise program	Objective evaluation (Assessment tool)	Sample and age (Average age)	
Proprioception exercises combined with physiotherapy are more effective than physiotherapy in improving balance and reducing the risk of falls.	8 weeks/ 45 min/ 2 times a week	Electrical detection test	Proprioception exercise	Berg balance scale Biodex	n=14 control group Average age: 60.3 years n=14 intervention group Average age: 61 years	El-Wishy and Elsayed (2012) [24]
Aerobic exercise improves gait, reaction time and balance, but has no significant effect on fall risk.	12weeks/ 45 min/ 3 times a week	Total score of neuropathic symptoms	Aerobic exercise	Standing balance, ability to walk Simple hand/ foot reaction time	n=21 control group Average age: 58.7 years n=16 intervention group Average age: 58.9 years	Morrison et al. (2014) [31]
Foot massage improves the balance and range of motion of the ankle.	2 weeks / 30 min/ 3 times a week	Monofilament test	Thai foot massage	TUG Stand on one foot Foot range of motion	n=30 control group Average age: 57.8 years n=30 intervention group Average age: 57.6 years	Chatchawan et al. (2015) [26]
Balance exercises improve posture stability in the elderly with diabetic neuropathy.	10 sessions/ 30 min/ 3 times a week	Toronto test	Balance training	Biodex TUG Berg balance scale	n=17 control group Average age: 59.05 years n=17 intervention group Average age: 58.82 years	Eftekhar et al. (2015) [12]
Balance exercises and sensory exercises have a significant effect on maintaining postural stability and improving balance.	4 weeks/ 45 min/ 2 times a week	Vibration perception threshold	Balance and sensory exercises	Body sensor technology	n=16 control group Average age: 64.9 years n=16 intervention group Average age: 62.58 years	Grewal et al. (2021) [16]
Ball exercises are preferable to Frankel exercises on balance.	3 weeks/ 55 min/ 5 times a week	Michigan Test	Ball and frankle exercise	Stand on one foot Berg balance exercise Star balance test	n=20 control group Average age: 53.85 years Ball training n=20 intervention group Average age: 55 years Frankel Exercise Intervention n=20 Average age: 54.15 years	Rojhani et al. (2017) [32]

Output result	Practical intervention (duration/ time/ repeat)	How to diagnose	Type of exercise program	Objective evaluation (Assessment tool)	Sample and age (Average age)	
Proprioception exercises improve static and dynamic balance.	8 weeks/ 65 min/ 3 times a week	NA	Proprioception training	Functional access TUG Stand on one foot	>60 years n=8 control group Average age: 51.75 years n=8 intervention group Average age: 52.87 years <60 years n=9 control group Average age: 52.87 years n=12 intervention group Average age: 66.75 years	Ahmad et al. (2019) [25]
Short-term balance and strength training improve balance and reduce the risk of falls but has no effect on the quality of life.	8 weeks/ NA/ 1 time per week	Monofilament test Michigan Questionnaire	Strength and balance training	TUG 5 time sit to stand Functional access Static balance Range of motion of the knee	n=73 control group n=70 intervention group Average age: 40-79 years n=9 control group	Venkataraman et al. (2019) [20]
Hydrotherapy and massage exercises have a positive effect on improving balance.	8 weeks/ 60 min/ three times a week	NA	Hydrotherapy and Massage	Berg balance exercise	Average age: 35-58 years n=10 hydrotherapy intervention group Average age: 35-58 years n=10 massage intervention group Average age: 35-58 years	Shourabi et al. (2021) [28]
Aerobics in water and aerobics increase balance but aerobic exercise has a better effect on postural stability and proprioception.	12 weeks/ 60 min/ twice a week	NA	Aerobic Aerobic in water	Biodex	n=8 control group Average age: 35-60 years n=8 aerobic in water group Average age: 35-60 years n=8 aerobics group Average age: 35-60 years	Abasgholipour et al. (2021) [34]

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Output result	Practical intervention (duration/ time/ repeat)	How to diagnose	Type of exercise program	Objective evaluation (Assessment tool)	Sample and age (Average age)	
Yoga and balance exercises increase static and dynamic balance and reduce the risk of falls in people with diabetic neuropathy.	12 weeks/ NA/ three times a week	Vibration perception threshold	Yoga and balance exercise	Star balance test Stand on one foot Berge balance scale	n=14 control group Average age: 42-70 years n=11 yoga group Average age: 42-70 years n=10 balance exercises group Average age: 42-70 years	Kanjirathingal et al. (2021) [35]
Balance exercises with Biodex significantly improve functional balance.	6 weeks/ NA/ twice a week	Toronto test	Balance exercise	Berg balance scale TUG	n=38 Average age: 50-75 years	Najafi et al. (2012) [36]
There was no significant difference between Wii Fit and balance training in improving balance.	8 weeks/ 30 min/ twice a week	NA	Balance exercise Wii Fit exercise	TUG Berg balance scale Fukuda test	n=12 reflexology intervention group Average age: 52.75 years	Khushnood et al. (2019) [13]
Balance exercises improve balance indices in diabetics with neuropathy.	4 sessions/ each exercise 45 sec/ each exercise 5 repetitions	Electrical detection test	Balance exercise	Biodex	n=11 Youmiho intervention group Average age: 51.27 years	Akbari et al. (2011) [14]
Massage (reflexology an Youmiho) leads to increased balance as well as improved proprioception in patients with diabetic neuropathy.	6 weeks/ 30 min/ 3 times a week	Specialist	Reflexology massage	Sharpand Romberg Berg balance scale Goniometer	n=11 control group Average age: 52.45 years n=12 reflexology intervention group Average age: 52.75 years	Morrison et al. (2014) [31]



Output result	Practical intervention (duration/ time/ repeat)	How to diagnose	Type of exercise program	Objective evaluation (Assessment tool)	Sample and age (Average age)	
Aerobic and resistance training (weight training) improves neuromuscular function and balance and increases nerve growth factors in patients with diabetic neuropathy.	8 weeks/ 45 min/ 3 times a week	Michigan questionnaire and a specialist doctor	Aerobic and resistance training	TUG 5 time sit to stand Berg balance scale Nerve growth factor	n=10 control group n=10 aerobic group n=10 resistance group Average age: 61.7 years	Hamidi et al. (2015) [27]
An 8-week resistance training program in diabetic women with peripheral neuropathy increases muscle strength and balance.	8 weeks/ 60 min/ 3 times a week	Michigan questionnaire Physical activity questionnaire	Resistance training	Biodex dynamometer	n=10 control group Average age: 48 years n=10 intervention group Average age: 57.6 years	Hedayati et al. (2015) [21]
Combining exercise (strength, aerobics) improves balance and reduces the risk of falling in older women with diabetic peripheral neuropathy.	8 weeks/ 60 min/ 3 times a week	Michigan questionnaire	Balance training Strength training Flexibility training Gait training	Berg balance scale Falls efficacy scale-international	n=11 control group Average age: 59.4 years n=12 intervention group Average age: 64 years	Farhan et al. (2019) [29]
The circular exercise effectively improved balance and reduced the risk of falls in people with diabetic peripheral neuropathy.	12 weeks/ NA/ 3 times a week	Michigan questionnaire	Resistance training	Dynamic gait index Falls efficacy scale-international tandem	n=15 control group Average age: 40-70 years n=15 strength training group Average age: 40-70 years	Rezaei et al. (2012) [22]

### **3.2. The effect of strength-balance intervention exercises on balance of people with diabetic neuropathy**

Allet et al. (2010) examined the effect of a 12-week strength-balance training program on individuals with a mean age of 63 years. This study showed that balance-strength training in these people improves balance, gait speed, and muscle strength [18]. Kruse et al. (2010) also examined the effect of the exercises on lower body muscles. This study was performed on people with an average age of 66 years. The results showed that 12-week balance-strength training has a positive effect on balance in these people [19]. On the other hand, Venkataraman et al. (2019) examined the impact of this type of exercise program for eight weeks with an average age of 40-79 years, which showed that short-term balance and strength training improve balance and reduce the risk of falling [20]. Hedayati et al. (2015) also performed resistance training for eight weeks and three times a week in people with DPN with an average age of 57 years. This study showed that 8-week resistance training program increases muscle strength and balance [21]. Also, Rezaei et al. (2012) studied 15 people who did strength training for 12 weeks. They examined the components of the walking dynamics index, the international scale of falling and standing tandem. The results showed that circular exercises improve balance and reduce the risk of falls [22]. Since people with diabetic neuropathy experience a general decrease in skeletal muscle mass, there is a decrease in muscle strength and volume, a decrease in balance, and an increase risk of falls. So, strength training in these people seems necessary [23].

### **3.3. The effect of proprioception exercises and massage on the balance of people with diabetic neuropathy**

El-Wishy and Elsayed (2012) studied the effect of proprioception exercises on balance in people with DPN and used Biodex and Berg balance scale to check the balance in these people. The activities were performed for eight weeks and twice a week. This study showed that these exercises have a more significant effect on improving balance and reducing fall position than physiotherapy [24]. Ahmad et al. (2019) reported that proprioception exercises improve static and dynamic balance in individuals with a mean age of 66.75 years. They concluded that these exercises were performed for eight weeks [25]. On the other hand, the results of Chatchawan et al. (2015) showed that foot massage improves the balance and range of motion of the ankle [26]. Also, Hamidi et al. (2015) examined 23 people with DPN in a mean age of 52-75 years. The results showed that massage (reflexology and Yumeiho massage) leads to increased balance and improved proprioception in these people [27]. Shourabi et al. (2021) performed massage exercises on nine people with neuropathy for eight weeks. The results showed that massage is one of the ways to increase balance and to improve the sensory system; so, using massage therapy in these people has had positive results in terms of improving balance and increasing proprioception [28].

Since proprioception is one of the neurological factors influencing the maintenance of the standing position of the body, proprioception information from the environment plays a crucial role in controlling balance, especially in the absence of visual and atrial sensation. The present study also showed that these

exercises in diabetic neuropathy increase proprioception and improve gait in these people.

**3.4. The effect of combined exercises (flexibility, aerobics, balance, etc.) on the proportion of people with diabetic neuropathy**  
Farhan et al. (2019) examined the effect of exercise (balance, flexibility, walking, and strength) in these people with an average age of 64 years. The results showed that combined exercise (strength, aerobics) improves balance and reduces the risk of falling [29]. Khanbabazade et al. (2015) [30] and Morrison et al. (2014) [31] studied aerobic exercise in people with DPN and concluded that aerobic exercise improves gait, reaction time and balance. Rojhani et al. (2017) examined ball exercises and Frankel exercises. The activities were performed for three weeks. The results showed that they are preferable to Frankel exercises to improve the balance of ball exercises [32].

On the other hand, Ahn et al. (2012) practiced Taichi for people with DPN, 12 weeks and twice a week. The results showed that these exercises increase balance and improve neuropathy symptoms [33]. Abasgholipour et al. (2021) performed aerobic exercises on land and aerobics in water for 12 weeks. The results showed that training on land has a better effect on improving balance and reducing the risk of falls [34]. Kanjirathingal et al. (2021) performed yoga exercises on 14 people with diabetes. The exercises were performed for 12 weeks and 3 sessions per week. The results showed that yoga exercises increase static and dynamic balance [35].

These exercises should be included in an exercise program to improve balance in people with diabetes and neuropathy.

#### 4. Discussion

The risk of falling due to decreased dynamic and static balance in these people is higher than healthy people. Researchers have considered poor balance as one of the critical factors in these patients and believe that balance is the basis for maintaining independence in the life of people with DPN. Exercise interventions are the most promising approach in improving balance disorders in patients with diabetes. So, this study aimed to systematically examine the effects of exercise interventions that are specifically designed to improve balance in people with DPN.

All studies focused on individuals with DPN showed that the effects of exercise interventions on static, dynamic balance were significantly higher than in controls. In addition, studies have shown that a training intervention lasting 2 to 12 weeks significantly improves the static and dynamic balance of individuals with DPN (pre-test to post-test). This can be due to the involvement of the body's sensory systems.

##### 4.1. The effect of balance and profundity intervention programs on balance of people with diabetic neuropathy

Balance dysfunction, fall, and fall-related injuries can be direct and indirect complications of DPN, which is caused by dysfunction of the proprioception function of the body sensory system [37]. In peripheral neuropathy, the extremities of the limbs are affected, causing a significant reduction in sensations such as tactile sensation, vibration, lower limb receptors, and movement sensations. Sensory, the presence and interaction of the sensory-visual and vestibular systems can effectively maintain stability, balance, and control of the person's position when standing and positional disturbances [38]. One study examined the effects of an

exercise program on the balance and torso of an elderly patient with diabetic neuropathy. They performed a balance exercise program for 60 min twice a week during eight weeks. The results showed that the subjects' body position fluctuation decreased significantly, and the static balance score on one leg and the depth sense score increased significantly [39].

#### ***4.2. The effect of power-balance intervention programs on the balance of people with diabetic neuropathy***

Research shows that resistance training increases peripheral muscle strength and balance in patients with peripheral neuropathy. Among the reasons for the increasing balance due to strength training, they are facilitating and synchronizing rapid contraction and large motor units, stimulating muscle spindles, reducing the self-controlling effect of the Golgi chord organs, and increasing the coordination of muscles involved in the co-contractile activity in studies expressed [40]. Loss of muscle strength also reduces balance and increases the risk of falls. The results of various studies show that between the ages of 30-80, the muscle mass of people with diabetes is reduced by 30 to 50%, which reduces muscle strength in lower limbs, and thus the balance is reduced [41]. Weight strength training also increases muscle mass and skeletal muscle growth and can improve neuromuscular function and balance and increase nerve growth factors in patients with DPN.

#### ***4.3. The effect of resistance-balance intervention programs on the balance of people with diabetic neuropathy***

Research shows that resistance training increases peripheral muscle strength and balance in patients with peripheral neuropathy. Among the reasons for the

increasing balance due to strength training, they are facilitating and synchronizing rapid contraction and large motor units, stimulating muscle spindles, reducing the self-controlling effect of the Golgi tendon organs, and increasing the coordination of muscles involved in the co-contractile activity in studies expressed [42]. Loss of muscle strength also reduces balance and increases the risk of falls. The results of various studies show that between the ages of 30-80, the muscle mass of people with diabetes is reduced by 30 to 50%, which reduces muscle strength in lower limbs, and thus the balance is reduced [43]. Weight strength training also increases muscle mass and skeletal muscle growth and can improve neuromuscular function and balance and increase nerve growth factors in patients with DPN.

#### ***4.4. The effect of combined intervention program, aerobic, and massage therapy on the balance of people with diabetic neuropathy***

Physical activity, especially aerobic exercise, is one of the main that reduce the symptoms of diabetes, among which walking is a priority. Walking requires no special equipment.

Exercises in the water act as a massage due to the hydrostatic pressure of the water, and these exercises also increase the depth of feeling, improve gait, and thus reduce the proprioception. In performing combined exercises (strength balance, flexibility, walking), people use practices with different features and shapes [44]. This variety is created in the movement, simultaneous performance of strength and balance exercises, flexibility. Aerobic and resistance exercises both can develop balance performance [30]. Also, in combination exercises, the athlete integrates proprioceptive receptors and

muscle coordination in co-contractile activities, and their performance is significantly increased.

## 5. Conclusion

These people have less balance than healthy people, which can reduce the quality of life. The present results show that the studied exercise interventions to improve static and dynamic balance in diabetic neuropathies are more effective than control conditions. Improving motor skills, especially balance, is more likely to help DPNs become more physically fit, which leads them to participate in a more physically active lifestyle. A more physically active lifestyle may lead to a better quality of life in people with DPN.

## Conflict of interest

The authors declared no conflicts of interest.

## Authors' contributions

All authors contributed to the original idea, study design.

## Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

## Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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