Review Article

Balance Problems in the Elderly with Diabetes Mellitus: A Literature Review

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Abstract

Diabetes mellitus (DM) is a syndrome of chronic metabolic disease which leads to all kinds of complications. Elderly people with DM have significantly higher fear of falling and balance problem scores as compared to those who did not have DM. This literature review aims: (1) to determine the risk factors for balance disorders in the elderly population with DM, (2) to describe valid and reliable balance measurement tools in the elderly population with DM, and (3) to describe the nonpharmacological management in dealing with balance disorders in the elderly population with DM. Several risk factors that cause balance disorders in the elderly with DM are related to complications of the disease they suffer, such as diabetic peripheral neuropathy, decreased sensory abilities, decreased motor skills, and decreased cognitive condition of the elderly with DM. Measuring instruments that can be used in the elderly population with DM to assess balance include the Mini-Balance Evaluation Systems Test, the Berg Balance Scale, and computerized measuring instruments with center of pressure analysis. Several nonpharmacological interventions are suggested in overcoming balance problems in the elderly with DM, including a combination of balance exercise and gait training, strength or resistance training, aquatic exercise, tai chi, yoga, technology-based exercise, electrotherapy, use of insoles, and whole-body vibrations.

Keywords: *Balance, balance assessment, diabetes mellitus, elderly, exercise, risk factor*

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Introduction

Diabetes mellitus (DM) is a syndrome of chronic metabolic disease that causes peripheral or central neuropathy. The prevalence of diabetic complications increases significantly with disease duration, age, and the patient's poor glycemic index. An observational study involving 100 elderly DM patients and 101 other elderlies without DM as a control group compared the level of balance and fear of falling (FoF) in the elderly. The results showed that elderly people with DM have significantly higher FoF and balance problem scores as compared to those who did not have DM. There was a significant effect on the Berg Balance Scale score in individuals with DM who also had neuropathic pain, hypertension, and cardiovascular disease.[1]

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Risk Factors of Balance Problem and Risk of Fall in the Elderly with Diabetes

Balance is one of the complex biomotor abilities. If someone experiences balance problems, it can cause falls, especially in the elderly.[1] The elderly with diabetes have significant balance disorders when compared to the elderly without diabetes.[2] A study shows an association between the incidence of type 2 DM (T2DM) with diabetic peripheral neuropathy (DPN) to the risk of falling or balance problems[3,4] and physical fitness in the preelderly and elderly.[4] Other studies prove that elderly people who experience T2DM with DPN have

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the potential to experience a decrease in sensorimotor function and walking stability.[5]

An observational study of 296 T2DM patients without DPN showed that the degree of sensory impairment was associated with an increased imbalance and risk of falling.[6] Balance problems are one of the complications in DM patients in the young and old age range. In all age groups, severe impairment of balance ability is associated with the development of microvascular complications of diabetes. The results of this study also explain about a longer duration of having diabetes, higher TUG test score, and female sex were related to a history of falls.[7]

In the evaluation of reactive balance control that compared groups of healthy young people, healthy elderly without DM, and elderly with DM, it was found that the elderly with DM experienced a decrease in reactive balance control where these changes were associated with muscle weakness and plantar insensitivity.[8] There is also a study that analyzes the potential for balance disorders and the risk of falling that occurs in individuals with T2DM who have not experienced DPN. This study proves that elderly people with T2DM without DPN experience decreased somatosensory and vestibular function, low levels of physical activity, and significantly lower static balance results when compared to elderly people without T2DM, thereby increasing the risk of developing balance problems in the future.[9]

The incidence of previous falls and female gender is a significant predictor of falls in the elderly with DM. The incidence of falls in the elderly with DM is related to the diabetic neuropathy score, glycosylated hemoglobin (HbA1c) level, tactile sensitivity, quadriceps strength, postural sway, tandem balance, stride length, and Timed Up and Go Test.[10] Other studies have observed a higher incidence of falls in the last 12 months in the DM group than in the control group in the elderly. Several diabetes complications, lower mini-mental state examination, activities of daily living (ADL), and instrumental ADL scores are associated with decreased balance function in older adults with DM.[11] In long-term elderly care, diabetes is a risk factor for falls in this population. There is a significant difference in the incidence rate of falls in the elderly with or without DM, i.e. 78% versus 30%. In a multivariate analysis, diabetes and Berg balance score < 45 was significantly associated with an increased risk of falling.[12]

Other studies evaluated the relationship between FoF, lower extremity (LE) muscle strength, and physical performance in the older adults without DM (ONDM) and the older adults with DM (ODM) to various levels of balance disorders. The results showed that FoF was present in 30% of ONDM and 60% of ODM. The modified Clinical Test of Sensory Interaction and Balance (mCTSIB) values can distinguish various degrees of balance disturbance among ODMs. The higher the level of the proportion of participants with FoF, the greater the level of failed performance in mCTSIB. The psychosocial domain of FoF, LE muscle strength, and TUG scores differed significantly between groups and was more affected in ODM with a greater number of failed performances in mCTSIB. LE muscle strength, FoF, and physical performance are more affected as the degree of balance disturbance increases.[13]

Individuals with T2DM often experience problems with sensory input which in turn can affect balance, such as decreased somatosensory, vestibular, and visual functions. Hyperglycemia conditions stimulate metabolic interactions that cause endoneurial hypoxia and alter nerve perfusion, especially to the peripheral nerves, and increase the risk of DPN. DPN has a very large influence on the body's perception of sensory input. Diabetic retinopathy plays a role in influencing sensory receptors in the retina which are related to visual input from the surrounding environment. Reduced sensitivity in the vestibular region can also change the perception of movement and balance in individuals with DPN. Furthermore, a condition like prolonged hyperglycemia affects the decrease in muscle strength, joint stiffness, and early degenerative processes in the brain.[14]

A study explains that cognitive function scores are lower in individuals with DM accompanied by worse balance disorders than individuals without DM. This study involved a population group, with an average age of 60 years.[15] Cognitive impairment is a risk factor for balance disorders and falls in the preelderly and the elderly. Individuals with cognitive impairments are 2 times more likely to experience falls compared to individuals without cognitive impairments.[16] A summary of the risk factors of balance problem and falls in the elderly with diabetes is shown in Table 1.

Balance Assessment in the Elderly with Diabetes

Measuring or assessing balance is an integral component of clinical assessment in the elderly population with T2DM. Various forms of examination and measurement are available. However, it is still uncertain which examination or measurement is most appropriate in this population.[14] Balance is defined as the integration between sensory input and the body's mechanical systems that interact with systems in the body, especially the nervous system within a constantly changing

Table 1: Risk factors of balance problem and risk of fall in the elderly with diabetes

Risk factors of balance problem
DPN[3,4]
Sensory impairment[6]
Muscle weakness[8]
Plantar insensitivity[6,8]
Decreased somatosensory and vestibular function[9]
Low levels of physical activity[9]
Significantly having lower static balance[9]
Several diabetes complications[12]
Lower MMSE[12]
Lower score in ADL assessment[12]
Lower score in IADL assessment[12]
Decreased in LE muscle strength[13]
FoF[13]
Decreased in physical performance[13]
Risk factor of fall risk
DPN[3,4]
Sensory impairment[6]
The longer duration of having diabetes[7]
The Timed Up and Go Test scores are higher[7,10]
Female gender[7,10]
The incidence of previous falls[10]
Diabetic neuropathy score[10]
HbA1c level[10]
Tactile sensitivity[10]
Quadriceps strength[10]
Postural sway score[10]
Tandem balance[10]
Stride length[10]
Berg balance score <45[12]

MMSE: Mini-mental state examination, ADL: Activities of daily living, IADL: Instrumental ADL, HbA1c: Glycosylated hemoglobin, LE: Lower extremity, DPN: Diabetic peripheral neuropathy, FoF: Fear of falling

environment or task. Based on this explanation, 6 main components needed in maintaining postural control are expected to be evaluated in a balance measurement tool. These six components include (1) constraints on the biomechanical system, (2) movement strategies, (3) sensory strategies, (4) orientation in space, (5) dynamic control, and (6) cognitive processing.[17,18]

Several measurements of balance have been used in the T2DM population, including dynamic balance test, balance walk, Functional Reach Test, tandem and unipedal stance, Berg Balance Scale, Tinetti Performance-Oriented Mobility Assessment, Clinical Test of Sensory Interaction and Balance, Timed Up and Go Test, the Dynamic Gait Index, and Activity-Specific Balance Confidence Scale. However, some of these tests and measurements do not assess all components of balance and most have not been validated in the T2DM population.[14]

The Mini-balance Evaluation Systems Test

The Balance Evaluation Systems Test (BESTest) measures six balance subscales, namely (1) biomechanical constraints, (2) limits of stability and verticality, (3) anticipatory postural adjustments, (4) postural responses to external perturbations, (5) sensory orientation during stance, and (6) gait stability, with a total examination duration of 30–45 min. The Mini-BESTest was developed to provide accurate test results, with a shorter examination time of 10–15 min. This examination includes four balance subscales, namely (1) transitions/anticipatory postural control, (2) reactive postural control, (3) sensory orientation, and (4) stability in gait. A cross-sectional study was conducted on 44 T2DM patients (4 males and 40 females, with a mean age of 56 years). The results showed that the Mini-BESTest can be used in clinical applications as a highly reliable and valid measurement tool for measuring balance in populations with type 2 DPN.[19]

Berg balance scale

One study involved 268 elderly people in the community who were 65 years or older, with an average age of 73 years. This study included elderly people with comorbidities such as high blood pressure, diabetes, heart disease, arthritis, vision problems, and hearing problems. This study shows that the Berg Balance Scale is valid and reliable in measuring balance in the elderly in communities where tandem stance and one-legged stance are the most challenging items to do.[20]

Modified Wii balance board

Force platforms are used as a gold standard in clinical practice, because they can measure limits of stability and center of pressure (CoP). CoP measurement provides an overview of body sway using metrics and graphs. However, the use of this measuring instrument requires a relatively high cost, is complicated to use, and lacks portability. Researchers observing the use of modified Wii Balance Board (mWBB) in assessing static balance through CoP in the elderly. This study involving an elderly population with complete or partial visual impairment, partial hearing impairment, diabetes, and hypertension. The results showed that mWBB has a high reliability score (intra-rater and inter-rater reliability) in measuring the static balance of the elderly through the CoP.[21]

Pedalo®-Sensomove balance device

Computerized measurement and feedback systems that assess static and dynamic balancing performance are widely available. However, this scoring system is expensive compared to the Pedalo®-Sensomove balancing system. A study was conducted to evaluate the

validity and responsiveness of the CoP range and CoP sway taken from the Pedalo®-Sensomove balance device in DPN patients with types 1 (n = 2) and 2 (n = 18) DM, with an average age of 60 years. The results showed that the CoP range and CoP sway measured by Pedalo®-Sensomove balance device are valid measures to assess balance in patients with DPN.[22]

Nonpharmacological Management in Improving Balance in the Elderly with Diabetes

Balance exercise

Meta-analysis shows that exercise intervention is more effective than the control group in improving static balance and LE strength in older adults with DM.[23] Another meta-analysis study with the DPN population in the age range above 41–60 years shows that a combination of exercises, such as gait training, balance training, and functional training, is effective in increasing balance, improving FoF, and quality of life in the DPN population.[24] Several types of training that combine gait training and balance training are useful in improving balance in individuals with DM. A randomized controlled trial (RCT) study reported providing training twice a week for 12 weeks with a total duration of 60 min per session. The training session is divided into 4 sessions: (1) warm up for 5 min, (2) circuit training for 40 min which consists of gait and balance training, (3) interactive games for 10 min, and (4) individual home exercise education for 5 min. The results showed that gait and balance training was proven to improve balance in individuals with DM in the age range of 63–64 years.[25]

Some elements of balance training that are suggested for individuals with DM and DPN include several aspects, such as implementation of training elements that involve proprioceptive, vestibular activation, and increased LE function.[26] A preexperimental study was conducted to determine the effectiveness of implementing somatosensory training by applying the 13-station technique with a variety of different textures by giving it 2 times a week for 12 weeks. The results showed that somatosensory training provided significant benefits to balance after 6 months which were evaluated using a CoP in individuals with T2DM.[27] Another study using proprioceptive training included in one of the somatosensory elements, with the application of the same frequencies (2 times a week for 12 weeks), showed that the application of this intervention did not show an increase in postural control in individuals with T2DM who did not experience DPN clinical complaints.[28] A study on a population of elderly women with T2DM also implemented proprioceptive training interventions. The results of this study indicate that proprioceptive training is proven effective in improving sensory function and CoP in elderly women with T2DM.[29]

Strength or resistance training

An experimental study compared the effectiveness of progressive resistance training (PRT) in 3 different populations, namely healthy individuals without diabetes, individuals with T2DM without DPN, and individuals with T2DM and DPN, with an average age of 62–63 years. PRT intervention was given 2 or 3 times per week for 12 weeks (30 sessions in total). The results showed that there were significant differences in the 3 populations who received PRT when compared to the control group (without PRT) in knee flexor and extensor muscle strength. While in the group of individuals with T2DM and DPN also experienced an increase in motor function which is measured by the six-minute walk test (6MWT) and five-time sit-to-stand test (FTSST), but the results of this study did not show significant differences in the balance variable as measured by the postural instability index.[30]

Aquatic exercise

The direct benefits regarding the benefits of aquatic exercise in improving balance in the elderly are yet to be determined. Several studies have proven the benefits of aquatic exercise in individuals with T2DM. A meta-analysis shows that 8 weeks of application of aquatic exercise is beneficial in improving glycated hemoglobin levels in adults with T2DM.[31] An RCT applied aquatic exercise to the elderly, 2 times a week for 12 weeks with graded intensities, and proved that aquatic exercise was beneficial for improving mental health, functional autonomy, and oxidative dysfunction in elderly people with T2DM.[32] Another study that directly measured balance, combined aquatic exercise with massage in the middle aged with DPN, showed that aquatic exercise combined with massage was able to increase nerve growth factor concentrations, improve glycemic profile, and increase dynamic balance in the middle aged with DPN.[33]

Tai chi

A single-arm trial study investigated the benefits of tai chi in 16 respondents. Tai chi was applied 3 times a week for 8 weeks. Tai chi practice is divided into 3 stages, namely 10 min of warm-up, 45 min of tai chi practice, and 5 min of breathing exercise. The results showed that there was a significant increase in ankle proprioception and fitness and decreased plantar pressure in the forefoot. There was no significant difference in balance or tactile sensation.[34]

Yoga

A pilot study examined the benefits of yoga for 8 weeks in 15 adult respondents with an average age of 66 years with the incidence of DPN on balance function, balance confidence, and occupational performance. The results showed that yoga is useful in increasing balance, balance confidence, and occupational performance in adults with DPN where large effect sizes are obtained in occupational performance.[35,36]

Technology-based exercise

Technology-based exercises are widely used as a form of training development in the diabetic population. Several types of useful technology-based exercise have been reported, namely the use of virtual reality training (VRT) and Wii Fit-based exercise (WBE).[37-39] VRT was applied twice a week for 10 weeks with a total duration of 50 min per session. VRT can significantly improve balance in the elderly with T2DM.[37,38] In the WBE intervention, respondents were trained using the Wii Fit Program. The study was conducted 3 times a week for 12 weeks with a total duration of 40 min per session. The study results show that WBE significantly reduces the risk of falling in older adults with T2DM.[39]

Electrotherapy

An experimental study compared the use of plantar electrical stimulation to a control group in improving postural balance and plantar sensation in individuals with DPN. Intervention is given by placing electrical stimulation on the plantar part for 1 h before going to bed, every day, for 6 weeks. There was an increase in balance and plantar sensation in individuals with DPN. This is proven by a significant increase in ankle and center of mass sway measurements with eyes open, gait parameters, and the vibratory plantar threshold in the intervention group that was given plantar electrical stimulation.[40]

Other studies have identified the benefits of adding monochromatic infrared photo energy to a combination of therapeutic exercise interventions and balance exercises. The intervention was carried out 3 times a week for 4 weeks (12 therapy sessions). The results showed that in the group of the addition of monochromatic infrared photo energy in combination with therapeutic exercise and balance exercise, provided more significant benefits in reducing pain, increasing sensation, and improving balance in individuals with DPN compared to providing training only.[41]

Insole

A systematic review concluded that insoles with tubing or vibration elements have a good effect on improving balance in the elderly with peripheral nerve disorders.[42] In another observational study, it was found that the insole design affected balance but did not increase the stepping reaction time in individuals with DPN. This study compared 4 uses of insoles, including (1) standard diabetic, (2) low resilient memory, (3) flat, and (4) textured. Standard diabetic and low resilient memory are associated with increased CoP velocity and path length when compared to the noninsole condition. Meanwhile, flat and textured insoles were not related to static balance when compared to conditions without insoles. This study concluded that the use of insoles is related to static balance where this effect does not depend on the severity of the neuropathy experienced by an individual.[43]

Whole-body vibration

An experimental study compared the effectiveness of adding whole-body vibration (WBV) to balance exercise on balance function, muscle strength, and HbA1c levels in elderly people with DPN. Balance exercise was carried out 2 times per week for 6 weeks with a duration of 60 min per session and WBV was applied 3 min × 3 min, 3 times per week, for 6 weeks. The results showed that the addition of WBV to balance exercise was beneficial in increasing balance, muscle strength, and improving HbA1c levels in elderly people with DPN.[44]

Conclusion

Elderly people with DM have significantly higher FoF and balance problem scores as compared to those who did not have DM. This was related to complications of the disease they suffer, such as DPN, decreased sensory and motor abilities, and decreased cognitive function. There are several measuring instruments that can be used to assess balance in the elderly population with DM including the Mini-BESTest, Berg Balance Scale, and computerized measuring instruments with CoP analysis. A combination of conventional or technology-based training and the use of insoles is associated with an increase in balance in the elderly with DM.

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Conflicts of interest

There are no conflicts of interest.

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