Research Article
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Impact of ankle joint mobility on balance performance in elderly type 2 diabetic subjects

Abstract

Background: Reduced range of motion at the ankle joint may be a risk factor for tripping and falling.

Objective: This study was conducted to evaluate the impact of ankle joint mobility program on the balance performance in elderly diabetic patients.

Material and methods: Forty elderly type 2 diabetic patients, age ranged 60-67 years participated in this study. Twenty subjects (training group) received ankle joint mobility training program for 6 weeks. The control group, included twenty subjects, received no training intervention and practiced their ordinary life style over the 6 weeks of the study. The ankle joint mobility was measured by the universal goniometer and the balance performance was measured by the Biodex Balance System.

Results: The mean values of overall stability, anteroposterior and mediolateral indexes during standing on both feet with head forward were significantly decreased which means improved postural stability, where dorsiflexion range of motion and planterflexion range of motion were significantly increased in group (A) which means improved ankle joint mobility, while changes in group (B) were not significant. In addition, there were significant differences between both groups at the end of the study. Moreover, Pearson's correlation coefficients test for the relationship between Biodex Balance System measured values (overall stability, anteroposterior and mediolateral indexes) and ankle range of motion (ROM) (dorsiflexion ROM and planterflexion ROM) at the end of the study in both groups showed a strong inverse relationship.

Conclusion: Improved ankle joint mobility enhances balance performance in elderly type 2 diabetic subjects.

Keywords: ankle joint mobility, balance, diabetes, elderly, stretching exercises

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Introduction

Globally, about 80% of worldwide elderly individuals live in the developing countries.[1] Aging lead to reduction of muscle strength reduced joint mobility and degradation of incoming sensory information that in turn may contribute to risk for falls in elderly.[2] Fear of falling and sustained serious injury is increased with advancing age, thirty percent of elders aged 65 years or more, half of them fall once per year. However, loss of self-confidence associated with falling leads to decreased activity and physical ability.[3] Risk factors for fall include balance dysfunction, muscular weakness, gait deviations and poor joint mobility, while among elderly is the second cause of death due to accidental injury all over the world.[4]

Diabetes is a common metabolic disease having serious health implications and its incidence is increasing day by day.[5] The global burden of diabetes is alarmingly high, with over 382 million diabetics in 2013, is expected to rise up to 592 million by 2035 and about 60% of the world diabetic population resides in Asia.[6] While, about 4-11% of African population according to estimation in 2015.[7] However, the prevalence of type 2 diabetes mellitus (T2DM) is more common among elderly people.[8] Poor control of T2DM adversely affect quality of life and increase economic burden due to increase rate of hospital admissions.[9,10]

Older individuals with type 2 diabetes often exhibited greater impairments in posture and gait and were typically increasing risks of falling. These impairments usually included atrophied leg muscles and plantar fat pad, development of claw toes, hammertoe and limited joint mobility.[11] These structural and functional abnormalities of the foot were associated with changed walk strategy and abnormal gait, eventually leading to an increased risk of falls that not only reduce mobility and independence in the elderly, but also cause substantial morbidity and mortality.[12] Proper leg strength and flexibility are important contributing factors to prevent falls in the elderly.[13]

The home based, individualized muscle strengthening and balance retraining program results in wide ranging of benefits. This program significantly lowered fall risk; lowered risk of moderate injuries, improved strength and balance measures, maintained physical activity level, and maintained of falls self-efficacy scores.[14] Therefore, fall programs in elderly subjects should include strength and balance training.[15] There are limited researches regarding flexibility exercise training in elderly.[16] However, comparative studies between strengthening and mobility studies reported significantly improved balance, while the underling mechanism for improving balance is unknown even limited ankle joint mobility is a principal cause for poor balance control.[17]

However, little is known about the balance problems in Egyptian elderly subjects, which could differ from that in the western countries owing to different life styles. Therefore, this study was conducted to evaluate the impact of ankle joint mobility program on the balance performance in elderly diabetic patients and to enable the physiotherapists to select the best appropriate treatment programs owing to better understanding of the relation of ankle mobility and balance performance in elderly diabetic subjects.

Material and methods

Subjects

Forty elderly type 2 diabetic patients, age ranged 60-67 years (65.13±4.62), participated in this study as they had been selected from patients follow up lists in diabetic outpatient clinics in Cairo University Hospital. Twenty subjects (training group) received ankle joint mobility training program for 6 weeks. Inclusion criteria included: history of diabetes mellitus, ability to lie supine, ability to walk independently without an assistive device and equal leg length. However, exclusion criteria included current or previous severe orthopedic injury to the lower extremity (e.g. ankle fracture, joint fusion, joint replacement) or a current or previous neurological insult (e.g. cerebrovascular accident). While, the control group included twenty subjects, that received no training intervention and practiced their ordinary life style over the 6 weeks of the study. The ankle joint mobility was measured by the universal goniometer and the Biodex Balance System measured the balance performance. These measurements were applied for both groups before and after 6 weeks.

Instrumentation

Biodex balance instrument: Biodex Balance System (Biodex medical systems Inc., Shirley, New York, USA) is a simple, efficient, commercially available balance screening and training tool. The system consists of a movable balance platform, which provides up to 20 degree of surface tilt in a 360-degree range. The Biodex Balance System helps to test and improve patients balance with a computerized "wobble board". Patients must use the feet and ankles to control an on screen cursor while the wobble board becomes unsteady. The computer analyzes the patient's movements and determines in which directions the patient is reluctant to move or is having difficulty moving. This directional weakness may be due to limited range of motion, muscle weakness or vestibular dysfunction.

The Goniometer: Clear plastic goniometer was used to measure ankle joint mobility (Range of motion for dorsiflexion and planterflexion).

Procedure

Balance assessment: Balance evaluation procedure had been explained to the patients based on the protocols set in the Biodex Balance System operation manuals. Balance test was performed with eyes opened. Next screen had shown patient centering procedure, where platform was set loose and patient was asked to assume the most comfortable position so that individual could control the platform and set a visual mark at the center of the screen in front of the individual. Balance test was then initiated and system started recording participants sway. However, the recording screen was divided into four quadrants and four circular zones. Therefore deviations from initial centered position was recorded together with its' direction and extent. Results were expressed as percentage of total test time participant spent on each zone and quadrant from which the device calculated an overall balance, mediolateral and anteroposterior indexes. According to evaluation, patients were categorized into four levels of stability according to the percentage of time each patient took in each of the zones A, B, C and D respectively, where A was the most stable and D the least stable level. Elderly diabetic patients had undergone balance testing using Biodex Balance System at laboratories of faculty of physical therapy, Cairo University, Egypt. The researcher was in charge of evaluation in addition to one assigned member of balance lab; appointment had been given according to the balance lab-working schedule. Patients were introduced to the lab at the scheduled dates, had taken the general knowledge about the system and revised the evaluation procedures prior to onset of evaluation.

Ankle range of motion assessment: Measurements of dorsiflexion and planterflexion range of motion took three times and the mean value was taken.

Ankle joint mobility program: One group of patients participated in this study, they received ankle-stretching exercises to planter flexor muscles and the duration of each session was 20 to 30 minutes for 3 sessions/week for 6 weeks as following:

A. **Gastrocnemius muscle self- stretching:** While the subject was in long sitting position with a towel positioned around the forefoot, he/she was instructed to actively dorsiflex the talocrural joint and then apply graded overpressure into dorsiflexion direction using the towel. Exercise was performed 3-5 times holding twenty seconds, then relax.

B. **Soleus muscle self-stretching:** While the subject was in sitting position at the edge of the bed with a towel positioned around the forefoot, he/she was instructed to actively dorsiflex the talocrural joint and then applies graded overpressure into dorsiflexion direction using the towel. Exercise was performed 3-5 times holding twenty seconds, then relax.

Statistical analysis

Paired t-test was used to compare mean differences between the initial and final evaluation of ankle joint range of motion and balance performance. Statistical analysis of data was performed using SPSS (Chicago, IL, USA) version 23. The degree of correlation between ankle joint range of motion and balance performance in elderly subjects with type 2 diabetes was detected by Pearson's product moment correlation coefficients (r) (P> 0.05).

Results

The baseline criteria statistical analysis revealed that there were no statistically significant differences in age, height, weight, body mass index, fasting blood sugar and postprandial blood sugar between subjects in both groups (Table 1).

Table 1 The baseline criteria of all participants

Characteristic	Mean +SD		T-Value	Significance
	Group (A)	Group (B)		
Age (year)	64.67±4.38	65.24±4.71	0.97	P>0.05
Height (cm)	167.22 ± 6.34	166.45±5.76	1.16	P>0.05
Weight (kg)	87.29 ± 5.11	88.98 ± 4.58	1.02	P>0.05
BMI (kg/m2)	32.87±2.54	33.15±2.67	0.85	P>0.05
FBS (mg/dl)	176.15±13.26	178.45±12.48	1.36	P>0.05
PPS (mg/dl)	248.43±19.51	251.16±20.72	1.45	P>0.05

BMI, Body Mass Index; FBS, Fasting Blood Sugar; PPS, Postprandial Blood Sugar

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The mean values of overall stability, anteroposterior and mediolateral indexes during standing on both feet with head forward were significantly decreased which means improved postural stability, where dorsiflexion range of motion and planterflexion range of motion were significantly increased in group (A), which means improved ankle joint mobility (Table 2), while changes in group (B) were not significant (Table 3). In addition, there were significant differences between both groups at the end of the study (Table 4). The Pearson's correlation coefficients test for the relationship between Biodex Balance System measured values (overall stability, anteroposterior and mediolateral indexes) and ankle ROM (dorsiflexion ROM and planterflexion ROM) at the end of the study in both groups showed a strong inverse relationship (Table 5).

Table 2 Mean value and significance of overall stability, anteroposterior and mediolateral indexes during standing on both feet with head forward before and at the end of the study in group (A)

Variables	Mean +SD		T-value	Significance
	Before	After		
Overall stability Index	2.87±1.13	2.45±1.11	3.92	P< 0.05
Anteroposterior Index	2.71±1.24	2.32±1.19	3.71	P< 0.05
Mediolateral Index	2.62±1.17	2.28±1.12	3.64	P< 0.05
Dorsiflexion ROM	14.58±2.26	18.13±2.81	4.87	P< 0.05
Planterflexion ROM	33.29±4.85	41.46±5.23	6.25	P< 0.05

ROM, Range of Motion

Table 3 Mean value and significance of overall stability, anteroposterior and mediolateral indexesduring standing on both feet with head forward before and at the end of the study in group (B)

Variables	Mean +SD		T-Value	Significance
	Before	After		
Overall stability Index	2.91±1.18	2.88±1.20	0.91	P>0.05
Anteroposterior Index	2.76±1.27	2.65±1.02	0.87	P>0.05
Mediolateral Index	2.68±1.22	2.59±1.01	0.75	P>0.05
Dorsiflexion ROM	14.75±2.31	14.72±3.00	1.14	P>0.05
Planterflexion ROM	33.81±4.76	32.64±4.58	1.21	P>0.05

ROM, Range of Motion

Table 4 Mean value and significance of overall stability, anteroposterior and mediolateral indexes during standing on both feet with head forward at the end of the study in group (A) and group (B)

Variables	Mean +SD		T-value	Significance
	Group (A)	Group (B)		
Overall stability Index	2.45±1.11	2.88±1.20	3.14	P<0.05
Anteroposterior Index	2.32±1.19	2.65±1.02	3.26	P<0.05
Mediolateral Index	2.28±1.12	2.59±1.01	3.12	P<0.05
Dorsiflexion ROM	18.13±2.81	14.72±3.00	3.65	P<0.05
Planterflexion ROM	41.46±5.23	32.64±4.58	5.31	P<0.05

ROM, Range of Motion

Table 5 The Pearson's correlation coefficients test for the relationship between Biodex Balance System measured values (overall stability, anteroposterior and mediolateral indexes) and ankle ROM (dorsiflexion ROM and planterflexion ROM) of group (A) and group (B) at the end of study

	Dorsiflexion ROM		Planterflexion ROM	
	Group (A)	Group (B)	Group (A)	Group (B)
Overall stability Index	0.653***	0.721***	0.626**	0.572**
Anteroposterior Index	0.542**	0.719***	0.695***	0.511**
Mediolateral Index	0.754***	0.592**	0.543**	0.714 ***

ROM, Range of Motion; Spearman's correlation was used *, P < 0.05 **, P < 0.01***, P < 0.001

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Discussion

Deterioration of joint mobility is one of the principle concerns among elderly diabetics.[18] Limited joint mobility is usually associated with poor quality of life and high risk for fall.[19] There is an association between aging and diabetes, that double the risk for fall during daily living activities as diabetes adversely affect circulation, mobility, muscle strength and proprioception sense over the ankle joints.[20] The aim of this study was to determine the changes in balance performance following the ankle joint mobility program in elderly diabetic subjects.

The results demonstrated that there were significant improvements in dynamic balance variables after ankle joint mobility training program, these results agreed with many previous studies as Tinetti et al.[21] showed that twelve weeks intervention including gait training, balance exercise and strengthening exercise improved balance scores among elderly subjects.[21] In addition Campbell et al.[22] stated that there is a significant reduction in fall efficacy scale scores after six months of strengthening exercise for lower limb and balance retraining program in elderly subjects. In this long-term program, the rate of falling among their older subjects reduced significantly through two years after program.[22] However, Lord et al.[23] reported that one hundred patients were tested and twelve community dwelling women aged from 60 to 85 years for 12 weeks. This program was divided into four sections: warming up, conditioning period, stretching followed by relaxation and activities for balance. They measured the dynamic postural stability pre-intermediate, and post program. They found postural stability improved after training.[23] While, Harada et al.[24] conducted a study on twenty-seven elderly subjects aged from 70 to 97 years that participated in a training program for four to five weeks; the results showed improvements in both Berg and Tinetti balance scale scores.[24] Similarly, Gardener et al.[25] designed an exercise program including strength, endurance, and balance exercise to improve balance in anteroposterior and mediolateral direction after two months. This program applied on 100 elderly subjects aged from 65 to 80 years old; they found that balance improved in anteroposterior and mediolateral directions.[25] Moreover, Rubenstein et al.[26] investigated the improvement in mediolateral balance control by using step up task. Each subject in this task placed the indicated foot onto step without transferring all of the body weight over foot as in stair ascent. After six week of this training program, they showed improvement in step up task.[26] Moreover, Bird et al.[27] concluded that 16 weeks of resistance and mobility exercise training program improved balance performance in elderly individuals.[27] Finally, Emilio et al.[28] proved that 12 weeks of proprioceptive training program significantly improved mobility, strength, balance performance, and reduced risk of fall in elderly subjects.[28]

Conclusion

Ankle joint mobility training program improves dynamic balance of community dwelling elderly diabetic persons. This study might be useful for reducing rate of falling and improving physical performance of daily living activities, because of independent lifestyle in these populations.

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Conflict of interest

Author states that there was no conflict of interest.

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