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The Effectiveness of Ankle Strategic Exercises on Risk of Fall Among Elderly Type-2 Diabetes Mellitus Individuals: An Experimental Study

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ABSTRACT

Introduction: Since falling is the third leading cause of chronic impairment, sarcopenia and its related fall risk are becoming more and more of a public health concern as our society ages. Falls have a positive correlation with morbidity and mortality and a negative correlation with independence and functionality. Diabetes mellitus is a group of heterogenous disorders characterized by hypoglycemia due to an absolute or relative deficit in insulin production or action. In type-2 diabetes mellitus (T2DM) low amounts of intramuscular non-contractile tissue (IMNCT) causes reduction in muscle strength. Individuals having type-2 Diabetes Mellitus since more than 6 years are reported to suffer from sarcopenia. Sarcopenia is defined as low muscle mass plus low muscle strength and/or physical performance. T2DM reports to cause loss of muscle strength in ankle plantar flexors and dorsiflexors too. Treatment for follow-up injuries from falls is expensive. Debating the effective physical training regimens to lower falls and their consequences is crucial. Muscle mass and muscle strength play a crucial role in daily activities and thus resistance training may positively and significantly benefit the elderly.
Method: 70 samples were collected (42 females and 28 males) were approached and consented for the intervention. A pre-intervention manual muscle testing, modified 30 seconds sit to stand test and SARC-F questionnaire was filled out by the samples. Post-intervention i.e. after 8 weeks, a Modified 30 seconds sit to stand test and strength testing was used to estimate and conclude the effectiveness of ankle strategic exercises on risk of fall in elderly T2DM individuals.
Result: Purposive sampling method was used in which results were calculated by Wilcoxon Signed Ranked Test. The P-value for the effectiveness of strength of ankle plantar flexors, dorsiflexors and Modified 30 seconds sit to stand was <0.001 which interpreted that an 8-week of ankle strategic strengthening protocol was significant; thus, accepting the H1 hypothesis.
Conclusion: It is concluded that there is a significant effectiveness of ankle strategic exercises on risk of fall among elderly type-2 diabetes mellitus individuals.

Keywords: Type-2 Diabetes mellitus, ankle strategic exercises, modified 30 seconds sit-to-stand test, sarcopenia, risk of fall

INTRODUCTION

Diabetes mellitus is a heterogeneous group of disorders characterized by hyperglycemia due to an absolute or relative deficit in insulin production or action.[1]

Type 2 diabetes mellitus affects our body by using glucose for energy. It stops the body

from using insulin efficiently, which can lead to high levels of blood sugar if not treated.

Low levels of insulin in type 2 diabetes mellitus patients are responsible for changes in skeletal muscles.[2]

Musculoskeletal complications are common in T2DM patients.

The most common musculoskeletal complication seen in type-2 diabetes mellitus is sarcopenia.[3]

Sarcopenia is defined as low muscle mass plus low muscle strength and/or low physical performance. [4]

Sarcopenia is associated with T2DM due to increased insulin resistance and impaired fasting glucose levels.[4]

Patients with diabetes have an increased amount of intramuscular non-contractile tissue (IMNCT), which is highly correlated with insulin resistance and a reduction of muscle strength.[5]

There is a progressive loss of muscle mass and muscle function over the age of 40 years. The muscle mass deterioration ranges are observed to be from 8% to 25%.[5]

The skeletal muscle requires insulin for glucose uptake in peripheral tissues to be used as energy or store in form of glycogen.

Sarcopenia lowers the glucose metabolism by insulin, leading to insulin resistance, thus making sarcopenia a factor contributing to exacerbation of T2DM.

Focusing on the musculoskeletal complications, a study showed that T2DM is associated with reduced muscle strength around ankle and knee joint. It also showed that there is a significant loss of muscle strength in ankle plantar flexors and dorsiflexors.[6]

In older adults, falls are primary cause of accidental deaths and nonfatal injuries. To identify older persons who are at risk of falling and to apply preventive interventions, previous researches have examined fall risk variables. There have been reports of several risk factors for falls in older persons, including a history of falls, having comorbidities, generalized deconditioning, muscle weakness and cognitive impairment.

Many tests have been used to predict the risk of fall in older adults (institutionalized as well as community-dwelling) but it was concluded that modified 30 seconds sit to stand test (m30STS) is more reliable in predicting risk of fall with upper extremity use over a year as it is also safe for the older adults.

Good strength of ankle plantar flexors and dorsiflexors is essential in performing the m30STS as those are the muscles that are mainly required in sit-to-stand activities and then later the trunk to progress forward.

Ankle strategic exercises are a group of exercises that are useful to strengthen the ankle muscles as well as to improve the balance and thus, the risk of fall.

The musculoskeletal complications are receiving less attention than the life-threatening microvascular and macrovascular complications of diabetes though these musculoskeletal complications are also important for maintaining the functional abilities of the elderly diabetics. [2]

In 2019, it was estimated that 90% individuals of total 451 million diabetic population had type 2 diabetes mellitus. As the population ages, the incidence of musculoskeletal disorders will also increase.[7]

However, many exercise programs designed to increase muscle strength and mass often require gym attendance, personal trainers, expensive machines, and a specific time creating potential barriers. Hence, there is a need to establish exercise therapy that can be performed at home in elderly patients with diabetes.[9]

The prevalence of reduction in ankle plantar flexors and dorsiflexors is 17% and 14% respectively.[6]

Strengthening the ankle plantar flexors and dorsiflexors in elderly diabetics might improve their functional mobility thus reducing their risk of falls.

In older healthful adults, resistance schooling the use of elastic bands or tubes because the resistive load has been proven to be as powerful as traditional resistance schooling the use of very own weight or weight machines.

Elderly people often have mobility issues and joint pains that prevent certain movements to be performed with proper technique. They can also have huge differences in the strength of different muscle groups. Depending on the activities they have been doing their whole life.

Some muscle groups can be so weak that performing typical strengthening exercises is not possible until those muscle groups have been made active again. This is where TheraBand exercises shine.

MATERIALS & METHODS

This was an experimental study conducted on 70 elderly individuals suffering from type-2 diabetes mellitus in and around Pune by purposive sampling within 6 months. The individuals selected were both males and females within the age group of 65-75 years having type-2 diabetes mellitus for minimum 6 years, SARC-F score ≥ 4, MMT of both plantar flexors and dorsiflexors ≤ 3, baseline MTSS score of below average (<11 for men and <10 for women), normal ankle plantar flexion and dorsiflexion ranges, ambulatory (without any assistance/ assistive devices like cane, walker, AND crutches). Individuals with diabetic neuropathy or any lower limb neuropathies, previous ankle or knee injuries, cognitive impairment (Alzheimer's, dementia), lower limb arthroplasty, any lower limb deformities (genu varum, genu valgum, pes cavus, pes planus, etc), vascular complication, retinopathy and cataract were excluded from this study.

PROCEDURE

The study started with synopsis presentation and ethical clearance from the ethical committee.

Participants were selected according to the inclusion and exclusion criteria of the study.

The study was explained and intervention was performed after the written consent of the samples.

Pre-intervention:

A SARC-F questionnaire was taken to diagnose sarcopenia. It included 5 components- strength (how much difficulty do you have in lifting and carrying 10 pounds/4.5kgs?), assistance in walking (how much difficulty do you have walking across the room?), rise from chair (how much difficulty do you have transferring from bed to chair?), climb stairs (how much difficulty do you have while climbing a 10 flight of stairs?) and falls (how many time have you fallen in past year?). each category was scored 0-2 (0- no difficulty, 1- some difficulty and 2- more difficulty). The individuals were scored accordingly.

All the individuals were tested for the ankle plantar flexors and dorsiflexors muscle strength. For this the oxford scale of manual muscle testing was used. For ankle plantarflexion, grade 3, 4 and 5, patient stood on limb to be tested and knee completely extended; no more that 2 fingers were used for external support. Patient was told to raise the heel (i.e. plantarflex the ankle) for 25 times. Grade 5(normal) was marked when the patient was able to do the repetitions as told; Grade 4(good) indicated when the patient completes any number of correct heel rises between 24 and 10 with no rest between repetitions and without fatigue; Grade 3(fair) conferred that Patient completes between nine and one heel rises correctly with no rest or fatigue. For grade 2, 1 and 0, the patient was in prone position with foot laid off the table. The patient was asked to point their toes down towards the floor and tries to hold the position at the end range. Grade 2+/2/2-(poor+/poor/poor-) varied from able to completing the whole ROM and holding the position at end range to completing only partial ROM. Grade 1(trace) indicated contractile activity of gastro-soleus tendon but no joint movement and Grade 0(zero) indicated no palpable contraction.

Modified 30 seconds Sit-to-Stand test, the individual was told to sit on a chair with armrest (seat height 17 inch and seat width 18 inch) and feet completely supported on the floor. When the timer of 30 seconds will

start, the individual was instructed to stand up completely with the help of the armrest and then sit down as many times as possible. The scoring of the test depends on the gender and is scored as below average, average, and above average.

AGE (years)	MEN (below average, average, above average)	WOMEN (below average, average, above average)
65-69	12; 12 – 18; >18	< 11; 11 – 16; >16
70-74	< 12; 12 – 17; >17	< 10; 10 – 15; >15
75-79	< 11; 11 – 17; >17	< 10; 10 – 15; >15

Intervention:

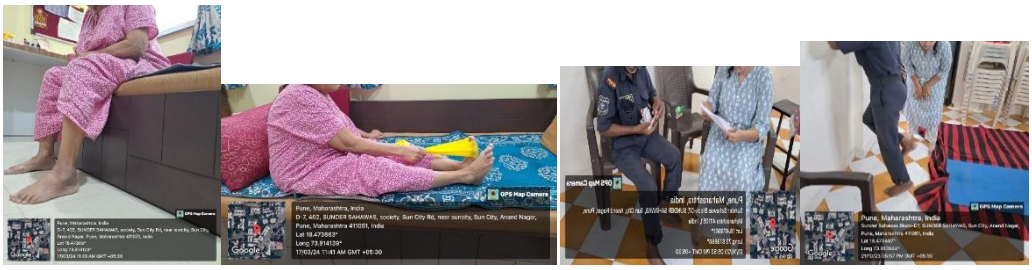
The intervention included mechanical strength training with the help of TheraBand/elastic band exercises. Five models [#TBB-1 (yellow), #TBB-2 (red), #TBB-3 (green), #TBB-4 (blue), and #TBB-5 (black)] of elastic band were used. Higher numbers indicate a larger resistance load, and the resistance of each band on 100% elongation was 1.3, 1.7, 2.1, 2.6, and 3.3 kg, respectively. The women who didn't exercise habitually were started with #TBB-1 (yellow); women who normally exercised were started with #TBB-2 (red) and all men were started with #TBB-3 (green). [11] The intervention time was for 8 weeks. 2 sessions per week for 2030 mins per session. The individual was told to do 2 sets per muscle group for 8-10 repetitions. [12]

Four exercises were conducted- the ankle 4-way exercise, ankle TheraBand alphabet exercise, heel raises with TheraBand and short foot exercise. The ankle 4- way exercise includes strengthening of the ankle muscles in all 4 directions. The ankle TheraBand alphabet exercise includes drawing alphabets by moving the ankle tied around with the TheraBand. In heel raises with TheraBand, the individual The subjects were told to raise their heels in standing. They were told to stand upright preferably close to a wall or their support area without necessarily touching it. The band was looped below their feet and hold the ends in both hands while maintaining some tension. Then they were told to slowly raise their heels up while supporting their body on their front feet alone. The short foot exercise was carried out by shortening the distance between the heel and the base of the hallux by sliding the forefoot posteriorly along the ground. The subjects were first told to be seated in a chair and then bring the thumb towards their heel trying not to curl up their toes. Then the same activity was performed in standing and single leg standing with one-hand support.

They were told to hold the position for 6-8 seconds sand increase the number of times the activity was performed. If required the thumb was brought close to the heel passively.

Post-intervention:

After the 8 weeks protocol of the intervention, the muscle strength of ankle plantar flexors and dorsiflexors and the Modifies 30 Seconds Sit-to-Stand test was re-taken and the results were interpreted and concluded.



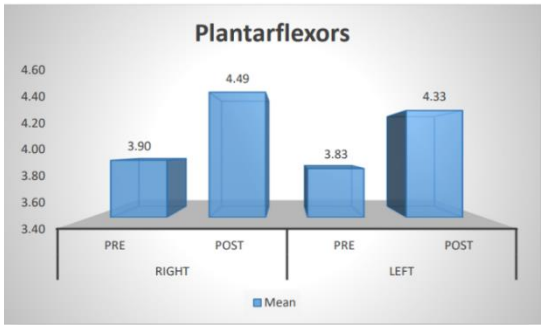
RESULT

PLANTAR FLEXORS:

Plantar flexors		mean	median	SD	SE	Wilcoxon value	P- value	% change	result
right	pre	3.90	4.00	0.55	0.07	-6.403	<0.001	15.24	Sig
	post	4.49	4.00	0.50	0.06				
left	pre	3.83	4.00	0.57	0.07	-5.916	<0.001	13.26	Sig
	post	4.43	4.00	0.53	0.06				

Table 1: Plantar flexors

Table 1 depicts that since observations are on ordinal scale, Wilcoxon Signed Rank Test is carried out to test significance in pre and post observations. From above table, we can observe that, P-Value is less than 0.001. Hence, we can conclude that, there is significant change observed post intervention.



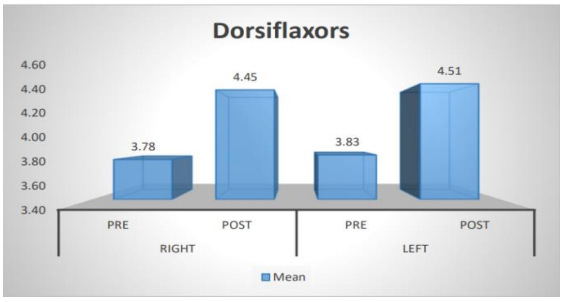
Graph 1: Plantar flexors

DORSIFLEXORS:

Dorsiflexors		mean	median	SD	SE	Wilcoxon value	P- value	% change	result
right	pre	3.78	4.00	0.54	0.06	-6.782	<0.001	17.62	Sig
	post	4.45	4.00	0.58	0.07				
left	pre	3.83	4.00	0.64	0.08	-5.856	<0.001	17.80	Sig
	post	4.51	4.00	0.61	0.07				

Table 2: Dorsiflexors

Table 2 depicts that since observations are on ordinal scale, Wilcoxon Signed Rank Test is carried out to test significance in pre and post observations. From above table, we can observe that, P-Value is less than 0.001. Hence, we can conclude that, there is significant change observed post intervention.



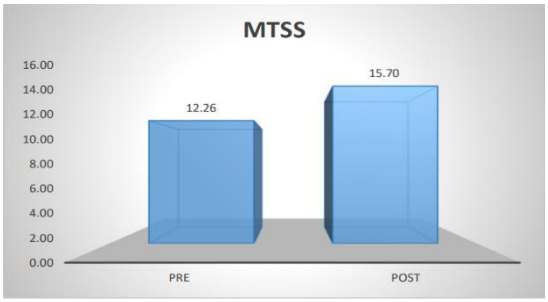
Graph 2: Dorsiflexors

MODIFIED 30 SECONDS SIT TO STAND TEST (MTSS):

MTSS	mean	Median	SD	SE	Wilcoxon value	P- value	% change	result
Pre	12.261	12.00	2.30	0.28	-7.397	<0.001	28.01	sig
Post	5.70	16.00	2.34	0.28				

Table 3: Modified 30 seconds It-to-Stand test

Table 3 depicts that since observations are on ordinal scale, Wilcoxon Signed Rank Test is carried out to test significance in pre and post observations. From above table, we can observe that, P-Value is less than 0.001. Hence, we can conclude that, there is significant change observed post intervention.



Graph 3: Modified 30 seconds Sit-to-Stand test

DISCUSSION

The current study is conducted to find the effectiveness of ankle strategic exercises on risk of fall among elderly type 2 diabetes mellitus individuals. Diabetes mellitus is a heterogeneous group of disorders characterized by hyperglycemia due to an absolute or relative deficit in insulin production or action. Sarcopenia is defined as low muscle mass plus low muscle strength and/or low physical performance. The individuals who suffer from type-2 Diabetes Mellitus also fall in the age group of 65 to 75 years have higher risk of fall due to sarcopenia. Low levels of insulin in blood affects the skeletal muscles; one of the complications being sarcopenia. Weakness in ankle plantar flexors and dorsiflexors may cause instability in the ankle joint, imbalance while walking and thus increasing the risk of fall.

There are previous researches done related to overall resistance training which includes Filipe Rodrigues et.al in 2022, concluded that the resistance training has shown benefits in several community dwelling elderly individuals which have increased their muscle mass and strength and have reduced the fall risk. [9]

Another study by Monirah M Almurdhi et al. in 2016 reported that individuals with T2DM have a significant reduction in distal leg muscle strength. There is a 1.5 times reduction in muscle force distribution of plantar flexors, dorsiflexors, invertors and evertors. Thus, focusing on the strengthening of these distal leg muscles is essential to reduce the risk of fall.[1]

Ankle strategic exercises are used when there is a modest movement in the ankle in upright standing position. The primary method of postural control is the contraction of the ankle joint muscles. The self- initiated sway which causes swaying from forward to backward and left to right without bending the body are methods to accelerate the ankle strategy.

Furthermore, there is a strong correlation between lower limb muscle strength and balance in elderly. Ankle strategic exercises are useful to strengthen the ankle muscles as well as to improve the balance of an individuals. Many studies have been conducted regarding the usage of ankle strategic exercises in chronic ankle instability which have promising results. [14]

A study on effects of strategic strength resistance exercises on isokinetic muscular function of ankle stated that strategic strength resistance exercises are necessary for functional stability of ankle joint and to maintain strength of the ankle joint. [14]

In addition to increasing the muscle strength, ankle strategic exercises also improve the proprioceptive ability which also aids in reducing the risk of falls.

It has been demonstrated that, under isometric plantar flexion, the force of the gastrocnemius and soleus muscle group, which is powerful ankle plantar flexor, is 30% lower in diabetic patients than in healthy individuals. Under isometric dorsiflexion force, the tibialis anterior, peroneus tertius, extensor digitorium and extensor hallucis all saw 26% reduction in force.

A study reports that in diabetic individuals' strength training increases the percentage of fast and slow twitch fibers. Moreover, strengthening also increases the amount of insulin in the skeletal muscles as a GLUT-4 protein's amount also increases which is responsible for insulin increment. [16]

Strengthening the weak distal muscles i.e. ankle plantar flexors and dorsiflexors also increases the muscle mass and ultimately reducing the sarcopenia and making the elderly individuals more functionally independent.

CONCLUSION

Based on this study, it was concluded that there is a significant effect of ankle strategic exercises on the risk of fall among elderly type 2 diabetes mellitus individuals.

Thus, proving the alternative hypothesis which stated that "there will be effectiveness of ankle strategic exercises on risk of fall among elderly type 2 diabetes mellitus within 8 weeks."

Declaration by Authors
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