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Effect of Different Treadmill Inclination Training on Postural Balance in Elderly

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Abstract

Background: Imbalance in elderly leading to frequent falling. This is a common and fatal problem in which increasing morbidity and mortality rate in society among the elderly. This study showed the effect of training on inclined treadmill with different angles of inclination on postural balance in elderly.

Aim of Study: To evaluate the effect of walking on treadmill with different angles of inclination on postural balance in elderly.

Subjects and Methods: Forty elderly patients of both sexes (21 males and 19 females) their age ranged from 60 to 70 years old were selected from orthopedic outpatient clinic of the Faculty of Physical Therapy, Cairo University. The patients were divided into two groups; each group consisted of twenty patients. Group (A) performed gait training on treadmill with 10% inclination then with 20% inclination in addition to simple program of static balance exercises 2 times/week and group (B) control group performed program of gait training on inclined treadmill with only 10% inclination in addition to simple program of static balance exercises. The balance was assessed by Biodex Balance Systembefore the beginning of the study and after 8 weeks of treatment.

Results: Statistical analysis of pairwise comparison test (time effect) for Biodex scores within each group showed that there were significantly (p=0.0001; p<0.05) decreased in Biodex scores at post-treatment compared to pre-treatment within study group with improvement percentage 31.54%. But, no significant difference (p=0.755; p>0.05) between pre- and post-treatment Biodex scores within control group with improvement percentage 8.01%. Moreover, study group improved higher Biodex scores (31.54%) than control group (8.01%). So, this significant decrease in Biodex scores at post-treatment is favorable of the study group than the control group.

Conclusion: It was found that walking with different angles on inclined treadmill was helpful in improving postural balance in elderly >60 years.

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Key Words: *Treadmill – Elderly – Falling – Balance.*

Introduction

GOOD balance and ability of walking are an imperative skills of daily life activities. This requires complex integration of sensory information regarding the position of the body relative to the surroundings and the ability to generate appropriate motor responses to control body movement **[1]**.

Balance needs contributions from vision, vestibular, sense, proprioception, muscle strength and reaction time. There is progressive loss of functioning of these systems with increased age. This leads to balance deficits **[2]**.

Balance disorders represent growing public health concern due to the association with falls and fall-related injuries. Falls consider one of the most serious and costly problems associated with older adulthood. Falls can mark the beginning of decline in function and independence. It's the leading cause of injury-related hospitalization in older people **[3]**.

Aging process is characterized by decrease acuity of vision and hearing, and also decrease in muscle power, decrease bone density, increase arthritis changes in joints, reduction in respiratory functions and number of cells in brain and spinal cord **[4]**.

The force generating capacity of the skeletal muscles is reduced with aging. So, many old people have difficulty in performing activities of daily living. The observed loss of force production in elderly is the result of muscle atrophy and alternations in percentage of contractile tissues within muscles rather than deficits in muscle activation and firing rates **[5]**.

Falls are the leading cause of injury-related visits to emergency departments, and the primary etiology of accidental deaths in persons over the age of 65 years. The mortality rate for falls increases dramatically with age in both sexes, with falls accounting for 70% of accidental deaths in persons 75 years of age and older **[6]**.

The main risk factors of falling in elderly are age, sex, white race, house bound status, living alone, use of assistive device of walk as cane or walker, previous falls acute illness, medications, cognitive impairments, chronic conditions especially neuromuscular disorders and neurologic changes, reduced vision, decreased hearing, difficulty rising from chair, foot problems, environmental hazards, severe pain, risky behaviors, and physical limitations **[7]**.

Exercises are vital at every age for healthy bones. It increases muscle strength and improve coordination and postural balance. It has benefits on preventing falling, reducing bone fractures and lead to better overall health **[8]**. It improves the physiological variables such as aerobic power flexibility and balance. Enhanced aerobic fitness promote an increase in physical activity values and promote endurance. This results in loss of fatigue and decrease falling **[9]**.

Gait training helps build up lower body strength. It is an important element for good balance. Walking is safe exercise for most people in addition to it improving balance **[10]**.

Treadmill training delivers sensory inputs tothe spinal cord which mediate locomotor training.It improves lower limbs muscle strength and balance performance. It enhances cardiovascular, functional performance, and reduces energy expenditure **[11]**.

Regular treadmill training provides great of health benefits in older adults as in younger adults, including improvement in blood pressure, diabetes, lipid profile, osteoarthritis, osteoporosis and cognitive functions. Regular physical activity is also associated with decreased mortality and age-related morbidity in elderly **[12]**.

Walking on inclined treadmill puts your body to work much more than just walking at flat surface. It mimics the grade of natural uphill climb with perfectly even surface, free of divots, holes or plateaus. It consumes more calories which make it better for weight loss than walking on flat surface. Adjusting the incline feature is so easy on most treadmills **[13]**.

Treadmill inclination promotes angular alterations such as increase in hip, knee and ankle angles during initial contact and swing phase. It makes an increase in the amplitude of movement of the hip and knee joints as well as an increase in stance time of the lower limbs **[14]**.

Upslope walking increases the ankle dorsiflexion which occurs to accommodate the vertical orientation of the torso and pelvis during the ascent phase. This also contribute to improve dorsiflexion activation or mechanical properties of muscles involved in planter-flexion **[12]**.

The aim of this study was to detect the effect of walking on inclined treadmill with different angles in improving postural balance in elderly.

Subjects and Methods

Subjects:

The present randomized controlled trial was performed in an orthopedic outpatient clinic at Faculty of Physical Therapy, Cairo University from January 2021 to September 2021 for duration of 8 weeks for each patient in this study. Forty patients aged from 60 to 70 years old, clinically stable mentally and psychologically with body mass index ranged from 20 to 30 kg/m^2 were included in this study.

Patients with neurological disorders, cardiopulmonary disorders, metabolic disorders (Diabetes mellitus), hepatic diseases, endocrine, thyroid disease or suprarenal disease, renal disorders, any mentality disorders, any visual abnormality or hearing disorders were excluded. The patients were fully informed by the physiotherapist and all signed written informed consent form.

The patients were evenly divided into two groups. (1) (Study group A) comprised of (11 males and 9 females), their mean ± SD for age were 64.30 ±2.34 years, they were given simple program of balance training exercises in addition to gait training on inclined treadmill with 10% inclination, then with 20% inclination. (2) (Control group B) comprised of 20 patients (10 males and 10 females), their mean ± SD for age were 64.00±2.57 years, and they were given the same program of balance training exercises in addition to gait training on inclined treadmill with only 10% inclination. And overall stability index was measured before treatment and after 8 weeks of treatment.

Methods:

Assessment tools:

BIODEX Balance System (20 Ramsey Road Shirley, New York, 11967-4704).

Therapeutic tools:

Electronic Treadmill: Reebok.

Evaluation procedures:

The BIODEX Balance System:

- The test consisted of recording the patient's ability to control the platform variation from a perfectly balanced position. A large variation was indicative of poor control and balance. All patients were given an explanatory session before the evaluation procedure based on the protocols set in the BIODEX system operation manuals to be aware about the different test steps of the BIODEX system. Patients were asked to stand centralized on the locked platform bare feet.
- Each patient was tested on most stable platform (stability level 8) for 30s. The patients were informed to try to keep the platform in a centered position (Once the platform start to move) by changing the position of their feet to another position that keeps the cursor on the center of the screen grid at the visual feedback screen.
- Each patient was informed about the whole procedures before testing.
- All patients were tested bilaterally and with their eyes opened.
- Each patient was instructed to keep the platform level for 20 seconds and then rest for 10 seconds by sitting.
- This high stability level and reduced time was chosen to avoid falling in elderly.
- Each patient was required to complete three practice tests prior to the testing conditions to ensure that they were familiar with the instrument.
- Support rails were adjusted according to the patients' comfort and safety. Display height and tilt were adjusted, so each patient could look straight at it.
- All patients understood that this instrument would help them to assess their balance.
- The balance platform was locked at the start of each session.

The test was initiated and the system started recording sway values after introducing heelcoordinates and feet angles into the BIODEX system.

Treatment procedures:

Group A:

Treadmill:

The patients in the study group completed gait training on inclined treadmill 2 times/week for total 8 successive weeks. Each session lasted 30 minutes with mandatory 5 minutes break every 10 minutes of walking, patients were allowed additional rest if necessary but were required to walk total of 20 minutes for gait session to be considered completed. Each patient performed warm up session for 5 minutes by walking on the treadmill at self-selected speed and then they were given one minute rest before the training **[15].**

During the treatment session, the patient walked on the treadmill at speed which started from 1.2 up to 1.6m/sec, as when patient progress the speed was increased to the maximum tolerated speed by the patient while maintaining of upright posture through the gait cycle. Instructions were given to the patients to hold on the rails while walking if they felt uncomfortable of losing balance.

Each patient walked for 10 minutes with 10% inclination, then 5 minutes break, then walked with 20% inclination for 10 minutes.

Simple balance training exercises:

Group of simple balance exercises applied on all patients. These exercises included weight shifting and performing hip, ankle and step strategies as follows:

1- Standing on one leg (five seconds for 10 repetition).
2- Standing on toes.
3- Sit to stand.
4- Pushes from all direction.
5- Heal to toe.
6- Unilateral leg abduction from standing.
7- Mini squat to stand (about 20 degrees knee flexion).

Group B:

Treadmill:

The session started with 5 minutes warm up, then one minute break, then 10 minutes walking with 10% inclination followed by 5 minutes break and then 10 minutes walking with the same angle of inclination (10%). All patients walked with speed ranged from 1.2 to 1.6m/sec, as when patient progress the speed was increased to the maximum tolerated speed by the patient while maintaining upright posture through the gait cycle. Instructions

were given to the patients to hold on the rails while walking if they felt uncomfortable of losing balance.

Simple balance training exercises:

All patients did the same program of balance exercises as in group (A).

Statistical analysis:

Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed (p>0.05) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference (p>0.05). All these findings allowed to conducted parametric and non-parametric analysis. So, the patient's demographic data are normally distributed (p<0.05) and parametric analysis is done while, Biodex balance test is not normally distributed (p>0.05) and non-parametric analysis is done.

The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Quantitative age, weight, height, BMI, Biodex balance test data are expressed as mean and standard deviation. For qualitative gender data are expressed as number and percentage. To compare between both group by independent-*t* test for age weight, height, and BMI variables and chi-square test for gender variable. Wilcoxon signed ranks test used to compare between pre- and post-treatment for Biodex balance test within each group. Mann-Whitney U test used to compare between study group and control group at before and after-treatment for Biodex balance test variable. All statistical analyses were significant at level of probability ($p\leq0.05$).

Results

The present study was conducted to evaluate the effect of walking on inclined treadmill with different angles on postural balance in elderly. A total of 40 patients from both genders (21 males and 19 females) were distributed randomly into two groups (20 patients/group). The results of-patients' demographic data (Table 1) showed that there was no significant differences (p>0.05) in age (p=0.702), weight (p=0.508), height (p=0.563), BMI (p=0.684), and gender (p=0.752) between study group and control group.

Statistical analysis of pairwise comparison test (time effect) for Biodex balance test within each group (Table 2 and Fig. 1) showed that there were significantly (p=0.0001; p<0.05) decreased in Biodex balance test at post-treatment compared to pre-treatment within study group with improvement percentage 31.54%. But, no significant difference (p=0.755; p>0.05) between pre-and post-treatment Biodex balance test within control group with improvement percentage 8.01%. Moreover, study group improved higher Biodex balance test (31.54%) than control group (8.01%).

Statistical analysis of pairwise comparison test (group effect) for Biodex balance test between both groups (Table 2; Fig. 2) indicated no significant difference (p=0.786; p>0.05) at pre-treatment of Biodex balance test between study group and control group. However, there was significant difference (p=0.0001; p<0.05) at post-treatment in Biodex balance test between study group and control group. This significant decrease in Biodex balance test at post-treatment is favorable of the study group than the control group.

Table (1): Comparison of patients' demographic data between study group and control group.

Items	Groups		*p*-value
	Study group (n=20)	Control group (n=20)	
Age (year)	64.30±2.34	64.00±2.57	0.702
Weight (kg)	74.55±7.72	73.01±5.71	0.508
Height (cm)	165.05±4.97	164.05±5.83	0.563
BMI (kg/m^2)	27.37±2.84	27.13±2.73	0.684
Gender (males: females)	11 (55.00%): 9 (45.00%)	10 (50.00%): 10 (50.00%)	0.752

- Quantitative data (age, weight, height, and BMI) are expressed as mean ± standard deviation and compared by independent *t*-test.
- Qualitative data (gender) are expressed as number (percentage) and compared by chi-square test.
- *p*-value: Probability value. NS: non-significant.

Table (2): Comparison of pre- and post-treatment mean values of Biodex balance test within and between groups.

Variable	Items	Groups (Mean ± SD)		Change	*p*-value
		Study group (n=20)	Control group (n=20)		
Biodex balance Test	Pre-treatment	3.90±0.83	3.87±1.07	0.03	0.786
	Post-treatment	2.67±0.49	3.56±0.87	0.90	0.0001*
	Change	1.23	0.31		
	Improvement %	31.54%	8.01%		
	p-value	0.0001*	0.755		

Data are expressed as mean ± standard deviation (SD). *p*-value: Probability value. * Significant (p<0.05).

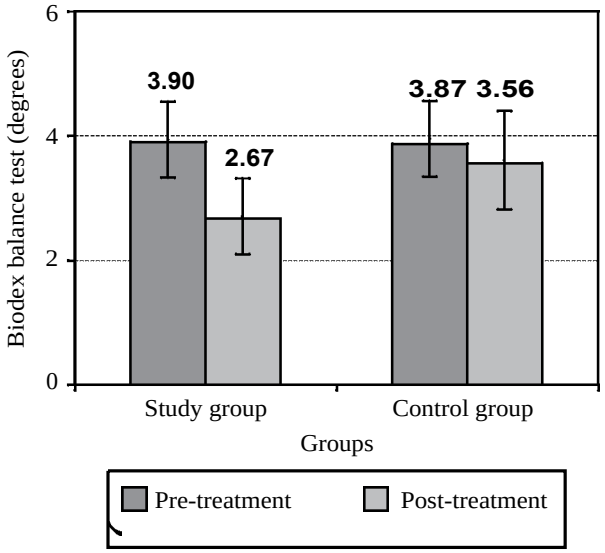

Fig. (1): Mean values of pre- and post-treatment Biodex balance test (degrees) within each group.

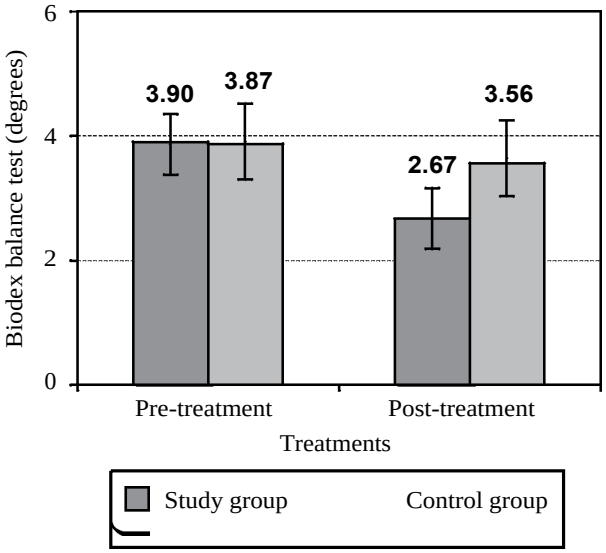

Fig. (2): Mean values of Biodex balance test at pre- and post-treatment (degrees) between both groups.

Discussion

This study was performed to determine the effect of walking on inclined treadmill with different angles on postural balance in elderly. Falling in older adults is complicated public health problem that can lead to impairments, disabilities, high cost to families and the society, and even death.

By comparing the mean values after therapy by Biodex Balance System, the results of the current study showed that findings could determine that walking on treadmill with different angles of inclination is an effective intervention in improving balance in older adults over 60 years, there was significant difference in the mean values after therapy between the two groups (A, B) (p>0.05). So, walking with different inclination angles on treadmill can be part of rehabilitation programs of balance in old people.

The results of Ferraro et al., **[16]** run in line with our results that during incline walking, the gait stability ratio (GSR) increased. There was more stability in gait pattern on inclines which decreased velocity and spent more time in the double limb support. There were clear changes were evident between level and incline surfaces regardless of fall risk.

Kim et al., **[17]** found that the activities of trunk muscles and quadriceps femoris muscle increased as the inclination of treadmill increased during walking. Also, Raiff et al., **[12]** discovered that walking on inclined treadmill helps in improvement of postural balance during gait as result of increased dorsiflexion to accommodate the vertical orientation of the torso and the pelvis during the ascent phase. This leads to improve dorsiflexion activation and mechanical properties of muscles involved in planter flexion. This improves ankle strategy which improving postural balance.

The study done by McIntosh et al., **[13]** found that there were changes in dynamics of the lower limbs with inclined walking. Inclined walking makes increasing in hip flexion and knee flexion and ankle dorsiflexion. These changes helped in theimprovement of the muscles involved in the joint action. This leadto enhance in postural balance in elderly. The mechanism by which the body enables walking uphill raising the center of mass had seen in the alteration in dynamics of the lower limbs and helped in increasing range of motion. Also, muscle strength requirements need to be required in improvements of postural balance in elderly.

The results in the current study agreed with Sung et al., **[14]** who found that treadmill inclination promoted angular alterations such as increase in hip, knee and ankle angles during initial contact and swing phase and an increase in the amplitude of movement the hip and knee joints, as well as an increase in stance time of the lower limbs.

It was found that walking on treadmill with different angles of inclination had an effective treatment in improving balance in elderly >60 years.

Ethical consideration:

All patients were told about the study's intent, existence, and potential risks before signing a written informed consent form.

A brief medical history of each patient was taken to ensure that they were not having chronic cardiac, respiratory problems, psychiatry or psychological disorders or advanced musculoskeletal disorders that might restrict and influence the results of the study. Physical Therapy Faculty Committee, University of Cairo, Egypt (No.: P.T.REC /012/002440).

Informed consent:

All patients in this study gave their informed consent before taking part.

Disclosure statement:

No author has a financial stake in or has benefited financially from this study.

Conflict of interest: There is no conflict of interest mentioned by the writers.

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تأثير التدريب بجهاز المشى وفقاً لتغيير درجة الانحراف على التوازن الوضعى فى كبار السن

الخلفية : ثبت أن عدم الاتزانفى المشى عند كبار السن يمثل مشكلة خطيرة قد تؤثر على وظائف الحياة اليومية بالإضافة إلى أن عدم الاتزان أو ضعف الاتزان قد يعرضهم إلى خطر الوقوع المتكرر وبالتالى يعرضهم لمشاكل صحية خطيرة تؤدى إلى عدم القدرة على إنجاز وظائف الحياة اليومية أو إلى الوفاة فى بعض الحالات.

الغرض من الدراسة : تقييم تأثير التدريب بجهاز المشى وفقاً لدرجات إنحراف متغيرة على التوازن الوضعى فى كبار السن.

الطريقة : شارك فى هذه الدراسة أربعون مريضاً من العيادة الخارجية للعظام بكلية العلاج الطبيعى، جامعة القاهرة، وتراوحت أعمارهم ما بين ٦٠، ٧٠ عاماً من كلا الجنسين، تم تقسيمهم عشوائياً إلى مجموعتين المجموعة أ (مجموعة الدراسة) كانت تضم ٢٠ مريضاً شاركوا فى برنامج تدريبى للمشى على جهاز المشى بزوايا إنحراف ١٠٪ ثم ٢٠٪ بالإضافة إلى برنامج تدريبى بسيط لبعض تمارين الاتزان لمدة ٨ أسابيع بواقع مرتين أسبوعياً. المجموعة ب (المجموعة الضابطة) كانت تضم ٢٠ مريضاً شاركوا فى برنامج تدريبى للمشى على جهاز المشى بزاوية إنحراف ١٠٪ فقط بالإضافة إلى برنامج تدريبى بسيط لبعض تمارين الاتزان لمدة ٨ أسابيع بواقع مرتين أسبوعياً. تم قياس الاتزان الوضعى لكل المشاركين فى الدراسة من المجموعتين عن طريق جهاز قياس الاتزان بيودكس قبل وبعد البرنامج العلاجى المكون من ٨ أسابيع.

النتائج : تحسن مستوى الاتزان الوضعى بنسبة ٣١.٥٤٪ فى مجموعة الدراسة (أ)، بينما كان التحسن فى مستوى الاتزان الوضعى بنسبة ٨٠.١٪ فى المجموعة الضابطة (ب)، وذلك طبقاً لقياسات جهاز البيودكس لقياس الاتزان.

الخلاصة : كان التدريب بجهاز المشى بزاويا إنحراف مختلفة له تأثير كبير فى تحسين الاتزان الوضعى لكبار السن مما يساعد فى تقليل مخاطر الوقوع المتكرر التى قد ينتج عنها إصابات أو وفيات.