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Effect of Specific Training Programmes on Hip Musculature Peak Torque in Osteoporotic Patients

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Abstract : Objectives: The aim of this study was to investigate the effect of core and treadmill training programmes on hip musculature strength in osteoporotic postmenopausal women. **Methods:** Twenty osteoporotic postmenopausal women ageing between 50 to 60 years with BMI between 20.2 to 24.9 kg/m^2 participated in this study. They were assigned randomly into equal groups. Participants of the group (A) received core training programme, while the group (B) received treadmill training programme lasting three months period. Hip flexors and extensors strength were assessed by Biodex system 3-pro dynamometer multi-joint testing and rehabilitation system, which measure the peak torques. The participants were tested twice; before and after the training programmes. **Results:** The statistical analysis revealed that there was a significant increase of the peak torque of hip extensors in the post-treatment condition compared with the pre-treatment one in both groups ($p<0.05$). Moreover, there was a significant increase of the hip flexors peak torque in the post-treatment condition compared with the pre-treatment one in group (B) only ($p <0.05$). However, there were no significant differences in the hip extensors peak torque between both groups ($p>0.05$). **Conclusions:** It can be concluded that the treadmill training programme is an effective treatment policy to strengthen the hip flexors and extensors in postmenopausal women.
Keywords: Core Training, Treadmill Training, Hip Muscles, Peak Torque, Osteoporosis.

Introduction

Osteoporosis is a progressive skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue resulting in an increased risk of fragility fractures[1]. Fragility fractures cause physical disability, impaired quality of life, increased mortality and higher health-care cost[2]. Furthermore, with reduced muscle strength and balance in elderly patients, there is an increased tendency of falling[3].

Physical activity has shown to increase muscle strength and bone mineral density (BMD), improves muscle control, balance and co-ordination and reduces the risk of falls[4].

Sinaki et al. (1988) [5] studied the relationships between muscle strength and BMD, and found a decrease in both BMD of the radius and strength of the elbow flexors with increasing age. However, they found a significant positive correlation between L2-L4 BMD and back extensor strength. Zimmermann et al. (1990) [6] found that the hip flexors peak torque is significantly correlated to the hip bone mineral density in postmenopausal women.

Core stability is important for appropriate balance of loading within the spine, pelvis, and kinetic sequence. "Core" is the group of trunk muscles that surround the spine and abdominal viscera. Abdominal, gluteal, hip girdle, paraspinal, and other muscles work in harmony to provide spinal stability. Core stability and its motor control are crucial for initiation of functional limb movements. Core strengthening, often called lumbar stabilization[7].

The musculature of the core is classified into "local" and "global" muscular systems. The role of "local" system is to control the curvature of the lumbar spine, and to maintain the mechanical spinal stability. It consists of all the muscles that originate and insert at the vertebrae, except the psoas muscles which flex the hip joint. While the "global" system acts to transfer forces from the thoracic cage and the pelvis to the extremities[8], and produce force because of large cross-sectional areas[9]. Some researchers have described the core as a double walled cylinder with the diaphragm as the roof, abdominals as the front, paraspinals and gluteals as the back, and the pelvic floor and hip musculature as the bottom[10].

Walking utilizes the entire lower body regions (the ankles, knees, and hips), and specifically the hip flexors, quadriceps, hamstrings, gluteals, gastrocnemius and soleus muscles[11]. The hip extensors play a major role in all ambulatory activities, stabilizing the trunk and hip and helping in transfer of forces from the lower extremities to the pelvis[12].

Core stability has an important role in dynamic balance of the elderly. Core muscle weakness is a factor which impairs the core stability of the elderly. Many therapists have conducted strengthening exercises such as trunk stabilization exercise in order to improve the core stability. However, there is a lack of scientific evidence about the effects of trunk stabilization exercise on muscle activations[13].

To our knowledge, no studies have used the core training for the aim of hip muscles strengthening in osteoporotic patients. So the main purpose of this study was to investigate the effect of core and treadmill training programmes on hip musculature strength in postmenopausal women. The current study might provide physiotherapists, clinicians and researchers the best type of training that enhances the hip musculature strength, and helps in prevention of fragility fractures of the hip region.

Materials and methods

Subjects

Twenty postmenopausal osteoporotic women aged between 50 and 60 years, and with body mass index (BMI) between 20.2 and 24.9 kg/m^2 participated in this study. They were with at least one year postmenopause and T-score of BMD (2.5 SD or more below the young adult mean). Patients with history of musculoskeletal problems, severe renal, hepatic, endocrine, cardiac impairments and uncontrolled hypertension or diabetes were excluded from this study. They were randomly assigned into two groups; first experimental "group A, n=10" and second experimental "group B, n=10". All participants gave written informed consent prior to participation in the study approved by Research Ethical Committee, Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/00469).

Instruments

Biodex system 3-pro dynamometer multi-joint testing and rehabilitation system (Biodex Medical System. Inc. Brookhaven technology Center. 20 Ramsay Road. BOX 702. Shirley. New York, U.S.A. 11967-0702), and treadmill (Quinton Fitness Equipment, Clubtrack, Fontana, CA,) was used in the current study for the treadmill training programme.

Testing of hip flexors/extensors' peak torque

A brief orientation session about the nature, aims and the tests of the study was accomplished to each participant. The assessment and treatment procedures were clear for all participants. Before performing the testing procedures, the data (age, weight, height, and calculation of BMI) were recorded for the participants. Each participant of both groups in the current study was assessed pre-treatment and post-treatment, after three months period of receiving core and treadmill training programmes. Hip flexors/extensors peak torques was assessed by Biodex system 3-pro dynamometer multi-joint testing and rehabilitation system. For testing the hip flexors and extensors' peak torque, the hip attachment was fixed and secured to the isokinetic dynamometer. Participants were assessed in functional standing position and the input axis shaft of the Biodex dynamometer was aligned superior and anterior to the greater trochanter of the participant when the limb in a neutral position. The dynamometer orientation and tilt were at zero degrees.

The participants were tested at the concentric flexion/concentric extension mode at an angular velocity of 60°/sec. Each participant performed the test through 45° of hip flexion and extension ROM. The participant was instructed to perform maximum flexion and extension with flexed knee all over the total determined range of motion. All participants performed one set of five consecutive maximal concentric hip flexors and extensors contractions. All participants received verbal encouragement. After the tests were performed, the results were printed in a report showing the peak torque.

Intervention protocols

Participants of the first experimental group (A) received core training programme three sessions weekly for three months period, 15 repetitions for each exercise at each session[14], inform of warm-up exercise and progressed core strengthening exercises; curl up, side-bridge, and bird dog.

The core training programme began with flexion-extension cycle (cat-camel) motion from quadruped position (5-8 cycles)[15]. Each participant began to perform the beginner's core stability program after performing the warm-up exercise. In the curl up exercise**,** the participant's hands were placed under the lumbar spine to preserve a neutral spine posture. One knee was flexed but the other knee was straight, and then alternates the bent leg (right to left) midway through the repetitions. The participant's head and shoulders were raised off the mat, so the motion was in the thoracic region only. Raising the elbows off the mat made the exercise more challenging. The participant was asked to hold the posture for 7-8 seconds without holding the breath[15].

The participant assumed side lying position on the right side in isometric side-bridge exercise. The right shoulder was abducted, so the upper arm was in vertical alignment on the ground and the forearm was rested on the floor. The pelvis was raised off the mat and held in a straight line "plank" position. The participant was asked to hold this posture for 7-8 seconds. The exercise was advanced by placing the upper leg in front of the lower one. The participant supported the trunk with resting the forearms on the floor, bending the elbows 90°, and resting the toes on the floor. The participant maintained the spine in a neutral position for 7-8 seconds. Instruction was given to the participant to roll and assume prone lying position on elbows and feet for 7-8 seconds. Finally, the participant was instructed to assume side lying position on the left side and perform the exercise as illustrated before[15].

The participant assumed the quadruped position on hands and knees and held the posture for 7-8 seconds in the bird dog exercise. While maintaining a neutral curve of the lumbar spine, the participant raised the right arm and left leg (opposite upper and lower limbs) in line with the trunk and holds this posture for 7-8 seconds with deep breathing. Lowered the hand and knee to sweep the floor with them and raised again for the next repetition. Then, the participant was asked to alternate sides[15].

While the participants of the second experimental group (B) received treadmill training programme, three sessions weekly. All treadmill training sessions were performed on a Quinton treadmill (Quinton Fitness Equipment, Clubtrack, Fontana, CA). A familiarization session of 5-10 minutes on the treadmill apparatus was done for the participants prior to the first session. The treadmill was set at no incline for the training period. Start the training session with a five minute warm-up on the treadmill at 45% of heart rate reserve (HRR, Karvonen method). After warm up, the effort was increased up to 65% of the subjects' HRR. Participants completed two miles per session at the first week, at the second week 2.5 miles per session, while at the third week three miles per session and the fourth week 3.5 miles per session[16]. The treadmill training programme was conducted for three months period with the same protocol of the first month.

Data analyses

It was intended to compare between both groups "between-subject effect" for the hip flexors, and hip extensors' peak torque in each of the "pre-treatment" and "post-treatment" conditions. Also, it was intended to compare between the "pre-treatment" and "post-treatment" conditions "within-subject effect" for these variables in each of the tested groups. Finally, the interaction effect was examined. 2×2 Mixed design MANOVA was used to determine whether there were significant differences in the set of dependent variables across the two experimental groups which received core and treadmill programmes and across the two times that measurements were taken.

Results

All statistical measures were performed using the Statistical Package for Social science (SPSS) program version 18 for windows. Prior to final analysis, data were screened for normality assumption, and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculation of the analysis of difference. To determine similarity between the groups at base line, participant's age, weight, height, and body mass index (BMI) were compared using independent t-tests.

The current study involved two independent variables. The first one was the tested group which had two levels (group A & group B). The second one was the measuring periods which had two levels (pre- and post-treatments conditions). The two dependent variables were the peak torque of hip flexors and hip extensors. Accordingly, 2×2 Mixed design MANOVA was used to compare the tested variables of interest at different tested groups and measuring periods. MANOVA was conducted with the initial alpha level set at 0.05

Demographic data of patients

As indicated by unpaired t-tests, there were no significant differences ($p>0.05$) in the mean values of age, weight, height, and BMI between subjects in both groups. The demographic data of the participants are shown in (Table 1).

Peak torque of hip extensors and hip flexors

Statistical analysis revealed that there was a significant within subject effect ($F = 20.795$, $p = 0.000$) but there was no significant between subject effect ($F = 0.615$, $p = 0.552$) and treatment*time effect ($F= 2.161$, $p = 0.146$). Table (2) represents the mean ± SD and multiple pairwise comparisons for all dependent variables in both groups in different measuring periods. Multiple pairwise comparison tests revealed that there was a significant increase of the peak torque of hip extensors in the post-treatment condition compared with the pre-treatment one in both groups, as illustrated in figure (1). While, there was a significant increase of the hip flexors peak torque in the post-treatment condition compared with the pre-treatment one in group (B) only ($p <0.05$), as illustrated in figure (2). Regarding between subject effects, multiple pairwise comparisons revealed that there was a significant increase ($p<0.05$) in the peak torque of hip flexors in group (B) compared with group (A), with no significant differences in the hip extensors peak torque between both groups ($p>0.05$).

Table 1. Descriptive statistics and unpaired t-tests for the baseline and demographic data of the participants in both groups.

	Age (years)	**Weight (kg)**	**Height (cm)**	**BMI (kg/m²)**
Group (I)	53.5±2.75	68.6±8.68	167.8±6.46	24.31±1.69
Group (II)	52.3±2.11	68.3±8.34	169.6±7.61	23.67±1.74
t-value	1.092	0.079	- 0.57	0.825
p-value	0.289	0.938	0.576	0.420

Table 2. Represents the descriptive statistics and multiple pairwise comparison tests (Post-hoc tests) for the peak torque of hip extensors and hip flexors in the pre- and post-treatment conditions for both groups.

Group B (N=10)		**Group A (N=10)**		**Dependent variables**
Post-treatment	**Pre-treatment**	**Post-treatment**	**Pre-treatment**	
84.89±17.35	60.33±18.51	82.88±25.86	59±21.15	Peak torque of hip extensors
72.97±15.76	56.25±20.63	58.12±13.11	58.81±12.09	Peak torque of hip flexors
Multiple pairwise comparisons between pre- and post-treatment values for all dependent variables				
Peak torque of hip flexors		Peak torque of hip extensors		Dependent variables
0.908		0.001*		Group (A)
0.011*		0.0001*		Group (B)
Multiple pairwise comparisons between group (A) and group (B) for all dependent variables				
Post-treatment		Pre-treatment		Measuring periods
Peak torque of hip flexors	Peak torque of hip extensors	Peak torque of hip flexors	Peak torque of hip extensors	Dependent variables
0.034*	0.841	0.739	0.883	Group (A) Vs. (B)

*Significant at the alpha level (p< 0.05).

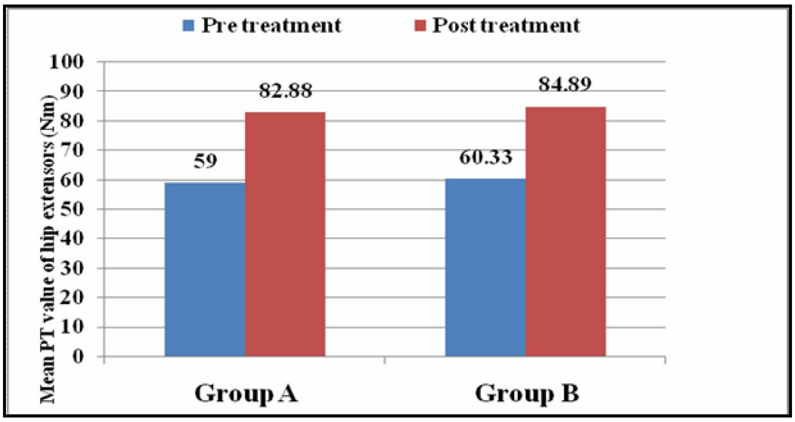

Figure (1). Mean values of the isokinetic hip extensors' peak torque (N.m) at 60˚/sec using the concentric mode of muscle contraction in the pre- and post-treatment conditions for both groups.

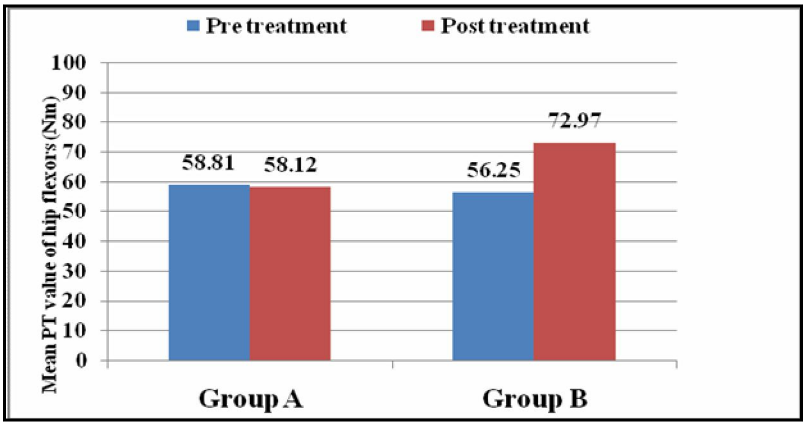

Figure (2). Mean values of the isokinetic hip flexors' peak torque (N.m) at 60˚/sec using the concentric mode of muscle contraction in the pre- and post-treatment conditions for both groups.

Discussion

The aim of the current study was to investigate the effect of core and treadmill trainings on hip flexors and extensors' strength in postmenopausal women. The peak torque was measured and the findings revealed that the treadmill and core training programme can help to increase the peak torque of hip extensors in postmenopausal women. Also, the significant increase of hip flexors peak torque in group (B) which received treadmill training compared with group (A) which received core training, indicated that the treadmill training had more effect on hip flexors' strength than the core training programme.

There is no literature concerning the effect of treadmill training on the tested variables of interest among the postmenopausal women. Some studies have reported that, the effects of core stabilization training on the trunk strength or the limb muscles vary with the muscles which examined even within the same body segments[17,18,19].

The findings of our study revealed that the core training programme can help to increase the strength of hip extensors in postmenopausal women. This finding was matched with the results of Hoshikawa Y. et al. (2013)[17] who studied the effects of stabilization training on trunk musculature and physical performances in youth male soccer players. The subjects performed a stabilization exercise program consisting of (elbow-toe, elbow-heel, side-bridge, modified 1-legged squat, and bent-knee push-up) 4 times per week for 6 months. A greater increase in hip extension torque was found in training group (40.8%) than in control group (17.4%), indicating that adding stabilization exercise to soccer training improves the hip extensors' strength. Also, agreed with our results in observing a significant gain in hip extension torque, but not in hip flexion torque.

Tayashiki K. et al. (2016) trained the young adult men with maximal voluntary co-contraction of abdominal muscles as a stabilization exercise for 8 weeks (3 days/week) consisting of 2-s maximal abdominal bracing followed by 2-s muscle relaxation (5×10 repetitions/day), and found that the stabilization exercise is an effective strategy for increasing the strength and power during movements involving the trunk and hip extensions[20].

Our results is consistent with the study of Nadler S. et al. (2004)[21] which demonstrated a significant increase in right hip extensor strength for 90% of athletes who participated in the study after incorporation of the core strengthening program emphasized abdominal, paraspinal, and hip extensor strengthening.

Conclusion

The conducted treadmill training programme was capable of improving the hip flexors' strength and its peak torque much more than the core training programme in postmenopausal women. Also, it can be concluded that the core and treadmill programmes had a beneficial effect on increasing the hip extensors' strength.

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