

## ORIGINAL ARTICLE

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## BACKWARD WALKING TRAINING IMPROVES KNEE PROPRIOCEPTION IN NON ATHLETIC MALES

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## ABSTRACT

**Background:** Walking is a popular, convenient, and relatively safe form of exercise. Humans generally learn walking in forward direction with little difficulty, while walking in backward direction is necessary for normal activities of daily living and accommodates the body with different tasks. This study was conducted to compare between forward and backward walking training on peak torque of Quadriceps and Hamstring muscles and their effect on knee proprioception.

**Methods:** Forty non athletic males, with mean age ( $21.87 \pm 1.76$ ) years participated in this study, and were classified into two equal groups. Group (A) walked forward on treadmill while group (B) walked backward three times/week for a total six weeks. They were assessed by using Biodex system 3 to measure the concentric peak torque of Quadriceps and Hamstring muscles at angular velocities 60 and 180°/sec and the knee joint proprioception. The assessment was done twice for every subject (pre-study and after six weeks of gait training).

**Results:** t-test revealed statistical significant increase in peak torque of Quadriceps and Hamstrings muscles in both groups after training at 60 and 180°/sec ( $p$ -value  $< 0.05$ ). There was statistical significant improvement in knee proprioception in group B only  $p$ -value was (0.000).

**Conclusion:** Both forward backward walking training improve the peak torque of quadriceps and hamstring muscles, while backward walking is better in improving knee proprioception accuracy.

**Keywords:** Backward Walking- peak torque - Quadriceps- Hamstring- knee Proprioception.

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## INTRODUCTION

Physical inactivity is one of the major problems in global health. Physical inactivity is the fourth leading underlying cause of mortality. There are 3.3 million people die each year around the world due to physical inactivity [1]. Physical activity is the main factor for maintaining and enhancing health. At least 30 minutes of moderate intensity physical activity on five or more days per week or 20 minutes of vigorous exercise on three days per week were recommend for preventing cardiovascular disease. Physical activities of moderate intensity, such as walking, jogging, and running can be incorporated into everyday life [2].

Endurance training in the form of sufficient walking training with little risk of overstrain has been established for injury prevention [3]. Walking is relatively a safe form of exercise, popular, convenient, and also described method for weight management [4]. The ability to walk backward is necessary for normal activities of daily living and allows the body to be positioned to accommodate different tasks. Backward locomotion for extended periods is used mainly for therapeutic or conditioning purpose [5].

The knee joint is the most vulnerable to injury in contact sports [6]. Therefore, knee performance is integral part in full and successful rehabilitation. Good muscle power, flexibility, balance and proprioception are important factors in order to insure a stable knee during various activities or sports. During backward walking (BW), the visual cues don't provide the subject with the visual information necessary to anticipate ground condition, and motor pattern are unconventional. Subjects have to reorganize and adapt the changed information from visual, cutaneous, proprioceptive, and vestibular senses, and then enhance the movement control to maintain dynamic balance [7].

Knee injuries pose serious health burdens to athletes of all ages in nearly every sport [8]. There are higher incidence rate of knee and knee ligaments injuries in males than females [9]. Most of knee injuries are requiring expensive surgical treatment [10]. Almost 50% of the patients suffering from knee injuries are between the ages of 20–29 years, which supports our study age range [11].

Ankle, knee and hip kinematic parameters of subjects walking backward or forward on a treadmill were reported by Vilensky et al (1987) [12]. Also Bates and McCaw (1986) compared ankle, knee, hip, and trunk kinematic parameters of subjects running forward and backward on a treadmill [13]. Whitley and Dufek (2011) examine the effects of backward walking on Hamstring flexibility and low back range of motion [14].

All of these studies didn't report effects of a training program of forward walking (FW) or BW on knee performance including proprioception and muscle torque. So this study was conducted to provide the physical therapist with the base line in rehabilitation intervention of the knee injuries concerning peak torque (PT) of Quadriceps and Hamstring muscles (ms) as well as the knee joint proprioception.

This study was designed to answer the following question, which has more significant effect on the strength of Quadriceps and Hamstrings ms and knee proprioception forward or backward walking training?

## MATERIALS AND METHODS

The institutional ethical committee of Faculty of Physical Therapy, Cairo University was approved this study. The study was done at the isokinetic laboratory and out clinic of Physical Therapy Faculty, Cairo University. Forty non athletic males, with age ranged from 18 to 28 years and BMI (20–25 kg/m<sup>2</sup>) participated in this study. All subjects signed a written informed consent form.

Exclusion Criteria include any history of lower extremity trauma or disease within the last six months, recurrent ankle sprain, sever cardiovascular problems that limit their ability to exercise [5].

Subjects were randomly assigned into two equal groups: Group (A): subjects performed FW training on a treadmill at speed from 1-2 m/sec. with 10° inclination for 15 minutes, three times per week, every other day, for six weeks. Group (B) subjects performed BW training on a treadmill at speed from 1-2 m/sec. with 10° inclination for 15 minutes, three times per week, every other day, for six weeks [15].

### Instrumentations:

#### 1- Isokinetic Dynamometer

The Biodex 3 isokinetic dynamometer is a multi-joint testing and rehabilitation system (Biodex medical system, Shirely, New York, USA). The system is equipped with adjustable chair for knee testing, adjustable straps to stabilize the knee and cuff to be attached two fingers above the lateral malleolus. This dynamometer provides a record of applied force throughout a joint range of motion, with accommodating resistance, also it measures knee proprioception.

#### 2- Treadmill Ergometer

Treadmill gait trainer (Biodex 950-M36, Shirely, New York, USA) is mainly motor driven, have a running table with sliding plate. There are two shafts before and after the race table. The running belt is extended between the running deck and the shafts.

### I- Evaluation Procedures:

Personal data was collected from each subject (name and age). The subject height and weight were measured by weight and height scale at isokinetic laboratory. Evaluation of isokinetic PT of Quadriceps and Hamstrings ms and knee proprioception was done with the Biodex 3 dynamometer for every subject before training and after six weeks of training.

#### A. Measurement of peak torque of Quadriceps and Hamstring muscles:

The dynamometer was turned on and then calibration and stabilization were done prior to each testing session. Before performing any test on the system, the apparatus was adjusted and set up to be ready for use. The subject was

secured on the seat by a ten cm wide strap was placed diagonally on the subject chest and thigh strap attach to the seat was used to stabilize the thigh. Subject seated on the dynamometer's chair with back rest is upright. The axis of rotation of the knee was aligned with the axis of the dynamometer's armature and the cuff was attached approximately two fingers above the lateral malleolus. Gravity correction was performed throughout the test. Participant positioned his arm beside his body, grasping the chair during the familiarization and testing according to the apparatus manual [16].

The testing procedure was explained to each subject before starting the test. Each subject allowed to do three light trial repetitions of knee extension and flexion before the test as a warm up and to familiarize with the system. The test was done in concentric mode for the dominant limb with range of motion from zero extension to 90 degrees of knee flexion. Each subject did maximum five repetitions of knee extension and flexion with angular velocity 60°/sec (muscular strength), followed by one minute rest then maximum twenty repetitions of knee extension and flexion with angular velocity 180°/sec (muscular endurance) [17].

#### B. Measurement of knee Proprioception:

Each subject was asked to sit on the chair of the Biodex system with his tested knee positioned in 90° of knee flexion. The lower leg was then passively moved to 45° of knee flexion. The limb was held at this angle for ten seconds and then passively returned to the starting point. The participant was instructed to actively replicate the previously positioned joint angle and lock the lever arm with a stop button, held in his hand, when the perceived reference angle had been reached. Three successive trials were done and the mean angular difference was recorded in degrees [18]. Subjects were closed their eyes and wear an eyeshade to prevent the visual feedback during the testing procedures [19].

#### II- Exercise procedures on treadmill

A warm-up period of five minutes in form of light jogging was done followed by five minutes rest. Then every subject performed 15 minutes training on treadmill at speed of 1-2 m/sec. with 10° inclination three times per week for six weeks [15,20].

The analyses of data include descriptive statistics of means and standard deviation of subjects characteristics. Paired and unpaired t-test were done for measured variables; PT of Quadriceps and Hamstrings ms at 60° and 180°/sec and knee proprioception for testing significant difference between two groups. All data analysis was performed using SPSS (version 20). The level of statistical significance was set at  $P < 0.05$ .

### RESULTS

The data in table (1) represent the mean  $\pm$  SD of age, height, weight and body mass index (BMI) of both groups. There was no statistical significant difference between two groups in their mean values of age, height, weight and BMI as p-value were (0.536, 0.88, 0.965 and 0.240) respectively.

**Table 1:** General characteristics of subjects in two groups

General Characteristics	Mean $\pm$ SD		t- value	p-value
	Group A	Group B		
Age (years)	21.7 $\pm$ 1.86	22.05 $\pm$ 1.66	-6.25	0.536
Height (cm.)	163 $\pm$ 6.2	163.3 $\pm$ 6.67	-0.147	0.88
Weight (kg.)	63.55 $\pm$ 4.13	63.45 $\pm$ 6.32	0.44	0.965
BMI (kg/m <sup>2</sup> )	23.86 $\pm$ 1.47	23.25 $\pm$ 1.74	1.194	0.240

**Table 2:** Pre training mean values of variables measured for both groups.

Items		Pre-training		t- value	p-value
		Group A	Group B		
PT of quadriceps (Nm)	60°/sec	114 $\pm$ 15.39	113.5 $\pm$ 6.4	0.121	0.905
	180°/sec	80.9 $\pm$ 13.04	82.5 $\pm$ 12.07 13.04	-0.399	0.692
PT of hamstring (Nm)	60°/sec	54.66 $\pm$ 6.55	55.5 $\pm$ 4.96	-0.454	0.652
	180°/sec	41.94 $\pm$ 9.56	42.05 $\pm$ 11.02	-0.032	0.975
Proprioception error		3.67 $\pm$ 1.02	3.82 $\pm$ 1.33	0.399	0.692

Data in table (2) showed there was no statistical significant difference between two groups pre-training in their mean values of PT of Quadriceps and Hamstring ms at angular velocities 60 and 180 °/sec, and knee proprioception.

**Table 3:** Post-training mean values of variables measured for both groups.

Items		Post-training		t- value	p-value
		Group A	Group B		
PT of quadriceps (Nm)	60°/sec	138.34 $\pm$ 25.38	127.85 $\pm$ 7.8	3.608	0.059
	180°/sec	91.36 $\pm$ 16.7	94.05 $\pm$ 7.5	-1.94	0.064
PT of hamstring (Nm)	60°/sec	70.42 $\pm$ 11.2	67.7 $\pm$ 7.5	-0.454	0.372
	180°/sec	52.25 $\pm$ 12.59	56.05 $\pm$ 5.16	-0.032	0.057
Proprioception error		3.59 $\pm$ 1.01	1.32 $\pm$ 0.76	0.399	0.000

As shown in table (3) there is no significant difference between the two groups in the post-training mean  $\pm$  SD of subject's PT of Quadriceps ms at 60°/sec and 180°/sec as p- value were (0.059, 0.064) respectively. Also, there is no significant difference between the two groups in the post-training mean  $\pm$  SD of subject's PT of Hamstring ms at 60°/sec and 180°/sec as p- value were (0.372, 0.057) respectively. There was significant difference in the mean values and SD of subject's Knee proprioception post-training in favor to group B where p-value was (0.000).

Data in table (4) shows the mean  $\pm$  SD of measured variables for group A, there were statistical significant differences in Quadriceps and Hamstrings ms PT between pre and post training at the two angular velocities, while there was no statistical significant difference in knee proprioception ( $P = 0.06$ ).

Data in table (5) shows the mean  $\pm$  SD of measured variables for group B between pre and post training, there were statistical significant differences in Quadriceps and Hamstrings ms PT at the two angular velocities and knee proprioception where p-values were (0.000).

**Table 4:** Pre-training versus post-training mean values of variables measured for group A.

Items		Group A			t-value	p-value
		Pre-training	Post-training	% of improvement		
PT of quadriceps (Nm)	60°/sec	114 $\pm$ 15.4	138.34 $\pm$ 25.38	21.3 %	-7.52	0.000
	180°/sec	80.9 $\pm$ 13.04	91.36 $\pm$ 16.7	12.9 %	-3.5	0.002
PT of hamstring (Nm)	60°/sec	54.66 $\pm$ 6.5	70.42 $\pm$ 11.2	28.8 %	-6.72	0.000
	180°/sec	41.94 $\pm$ 9.56	52.25 $\pm$ 12.59	24.6 %	-4.93	0.000
Proprioception error		3.67 $\pm$ 1.02	3.59 $\pm$ 1.01	2.2 %	2.001	0.06

**Table 5:** Pre-training versus Post-training mean values of variables measured for group B.

Items		Group B			t-value	p-value
		Pre-Training	Post-training	% of improvement		
PT of quadriceps (Nm)	60°/sec	113.5 $\pm$ 6.4	127.85 $\pm$ 7.8	12.6 %	-7.52	0.000
	180°/sec	82.5 $\pm$ 12.07	94.05 $\pm$ 7.5	14 %	-3.5	0.000
PT of hamstring (Nm)	60°/sec	55.5 $\pm$ 4.96	67.7 $\pm$ 7.5	21.98 %	-6.72	0.000
	180°/sec	42.05 $\pm$ 11.02	56.05 $\pm$ 5.16	33.29 %	-4.93	0.000
Proprioception error		3.82 $\pm$ 1.33	1.32 $\pm$ 0.76	65 %	2.001	0.000

## DISCUSSION

Gait training has been reported to be effective in enhancing the knee performance. This study was conducted to compare the effect of FW and BW training on the PT of Quadriceps and Hamstrings ms and knee joint proprioception. This study conducted on non athletic males to provide baseline data to know which better application FW or BW training as a rehabilitation protocol for knee injuries as regarding to muscular performance provided by Quadriceps and Hamstrings ms PT and knee joint stability provided by knee proprioception.

Forward walking is less difficult than BW due to less postural stability and absence of visual cues. But when com-

paring the rehabilitation outcomes of FW and BW, the last is greatly useful especially in improving muscle and neural activities. During BW; from initial contact to terminal stance the knee extensor muscles, rectus femoris, vastus lateralis and vastus medialis are contracted. The knee joint is extended during this stance phase in order to prevent descent of the body's center of mass [21,22]. During BW; there is simple knee joint displacement which decreases the power amplitude of knee joint [23].

It is noted that Quadriceps muscle torque decreases as angular velocity increases according to the classical force-velocity relationship, which explains the high values of Quadriceps muscle peak torque at 60°/second in comparison to the high velocity 180°/second [24].

The findings of this study are in agreement with Scott and Winter, (1990) who demonstrated that backward gait may be beneficial in the rehabilitation of patellar tendinitis through decreasing eccentric tension developed by Quadriceps muscle. While maintaining isometric and concentric knee extensor muscle strength [25].

The findings of this study disagree with khadilkar and Bedekar, (2011) who demonstrated that there was no statistically significant improvement of proprioception after backward gait, but there was statistically significant improvement in the 10 RM of quadriceps and hamstrings; but this study was performed in patients after anterior cruciate ligament reconstruction. [26] There is no previous study was done to investigate the effect of forward and backward gait on knee proprioception.

## CONCLUSION

It can be conclude that there was significant improvement in knee muscles performance after forward and backward gait training. Backward walking training has significant effect on knee joint proprioception than forward walking training.

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