

## ORIGINAL ARTICLE

## IJPHY

## KNEE JOINT PROPRIOCEPTION AND QUADRICEPS MUSCLE STRENGTH AMONG DIABETIC AND NON DIABETIC SUBJECTS

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## ABSTRACT

**Background:** Diabetes mellitus is a group of metabolic disorders characterized by increased blood sugar (glucose) levels (hyperglycemia) with absolute/relative deficiency in carbohydrate, protein and fat metabolism caused by defect in insulin secretion, action of insulin or both. Diabetes mellitus can be combined with problems/impairments which can lead to the decrease in muscles strength and proprioception specially, in the lower limbs. The purpose of the study is to investigate the knee joint repositioning accuracy as a measure of knee joint proprioception and peak torque of the quadriceps muscle as a measure of quadriceps strength between type II diabetic patients (in the first five years of the disease) and healthy subjects.

**Methods:** Thirty male subjects aged between 35–55 years old were included in this study; they were assigned into two equal groups, the study group which included 15 type II diabetic patients in early five years of the disease and the control group which included 15 healthy subjects. Active knee joint repositioning accuracy as a measure of knee joint proprioception and the isokinetic peak torque of the quadriceps muscle as a measure of quadriceps strength were measured for both groups by Biodex multipoint system, pro Isokinetic dynamometer.

**Results:** The unpaired t test results between the two groups showed no significant differences in knee joint repositioning errors where P-value was (0.319) and also there was no significant difference in quadriceps muscle strength between the control and study groups where the P-value was (0.157).

**Conclusion:** Knee joint repositioning accuracy and quadriceps muscle strength aren't affected in type II diabetes mellitus patients in early five years of the disease.

**Keywords:** Diabetes Mellitus, Knee joint, Knee Proprioception, Quadriceps Strength, Active repositioning accuracy, Isokinetic Dynamometry.

Received 10<sup>th</sup> August 2016, revised 05<sup>th</sup> December 2016, accepted 07<sup>th</sup> December 2016



www.ijphy.org

10.15621/ijphy/2016/v3i6/124746

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## INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by increased blood sugar (glucose) levels (hyperglycemia) with absolute/relative deficiency in carbohydrate, protein and fat metabolism caused by defect in insulin secretion, action of insulin or both [1,2]. Insulin is the hormone that produced by the beta cells in the pancreas, which is necessary to consume the glucose from the digested food to produce energy to supply the body [2,3].

The world wide diabetes prevalence has risen from 4.7% in 1980 to 8.5% in 2014 among adults over 18 years of age [4]. There are two types of DM, type I and II but the most common one is type II DM which the World Health Organization (WHO) estimates that the number of people with type II will be more than double by 2030, DM approximately affecting 366 million people [5] and it's one of the major causes of death in the worldwide, with increasing rate [6]. Chronic hyperglycemia is associated with macro-vascular and micro-vascular problems that can be cause of visual impairment, blindness, nephropathy, neuropathy, amputations, cardiomyopathy, strokes and features of autonomic disorder such as sexual dysfunction [6].

Proprioception can help in joint stability, postural correction (control) and many other conscious sensations. Proprioception involves the senses of joint position and joint motion; it includes various sensory systems of muscles, tendons, joints, ligaments, skin, and organs of vision and balance [7-10]. In DM some associated problems as Peripheral Neuropathy (PN) may affect and impair the whole body; however 50–80% of patients have lack of information of DM and its associated problems [11].

Diabetes mellitus can be combined with problems/impairments such as; metabolic inflexibility, insulin resistance and muscular/neuromuscular impairments, which can lead to the decrease in muscles strength specially, in the lower limbs. Reduction of the muscles strength, is associated with increase of nerve lesion (Neuropathy), glycated hemoglobin (HBA1C) and duration of the diabetes [12-13, 14-20]. Yoosefinejad and Haghighi, 2004, concluded that DM patients especially those with polyneuropathy have impaired knee joint proprioception, which could make the patients vulnerable to fall and could lead to subsequent fractures and increased the level of morbidity and mortality [21]. Ites et al., 2011, reported that, the diabetic polyneuropathy decrease the action and function of the peripheral sense receptors especially the muscle spindles which could lead to balance and gait stability disturbance and impairment [22]. The DM patients showed decrease of the reflex responses to postural perturbation, followed by decrease in the nerve conduction velocity, which lead to disturbance of the balance and increase the risk of falls [23].

Muscle weakness which has an uncommon manifestation in diabetes is associated with severe diabetic neuropathy. However, previous studies were cross-sectional observation. So, it was indistinct whether decreased muscle strength in diabetes is a result of diabetes or just a con-

currence<sup>12)</sup>. The effect of DM in early stages without neuropathy on knee proprioception and muscle strength hasn't been clearly reported. If this effect can be reliably reported, strength and proprioceptive training in early stages of DM could be recommended. The aim of the study was to test the knee joint repositioning accuracy as a measure of knee joint proprioception and quadriceps muscle strength between type II diabetic patients (in the first five years of the disease) and healthy subjects.

## SUBJECTS AND METHODS

Thirty male subjects with age from 35 to 55 years old were included in this study, and they were separated into two groups, group A included 15 normal subjects and group B included 15 subjects with type II diabetes mellitus within the first five years of the disease. Subjects were excluded who had back and knee joint diseases, previous knee surgery, knee deformities, polyneuropathy, in addition to athletic and smoker subjects. Active knee reposition accuracy and isokinetic quadriceps strength were tested for both groups. The ethical clearance was obtained from the Institutional Ethical Review Committee.

### Instrumentation:

Biodex Isokinetic dynamometer (Biodex Medical INC., Shirley, New York, USA), was used to measure the proprioception of the knee joint and quadriceps strength.



Figure 1: Biodex multipoint system

### Procedures:

#### Knee proprioception:

Proprioception accuracy as represented by repositioning accuracy was assessed for the dominant knee by the Biodex Multijoint system, pro isokinetic dynamometer (Biodex Medical Inc., Shirley, NY) through active repositioning test by testing the subject's ability to actively reproduce an angle at which the joint had been positioned before in non-weight-bearing position.

### Measurement procedure:

The subject was seated on the chair of the Biodex system and the tested knee was adjusted with the dynamometer's axis in 90° flexion (starting position), the subject was stabilized in the test position by straps around the trunk, pelvis and thigh and was blind folded to avoid visual input during the test and the tibial pad was secured to the shank 3 cm above the lateral malleolus. Type of test was (active repositioning test with speed 60°/s) with three repetitions of the test. Initially the anatomical reference angle was at 45° then the subject leg was return to the starting position [24].

For standardization, the tested limb was allowed to move to target angle (45°) actively [25], then was held for 10 seconds as a teaching process for the subject so the subject could memorize the position, and then the limb was allowed to return to the starting position [24]. Then the subject was asked to move his limb to the target angle (45°) actively, when the subject felt that he reached the target angle actively he was able to stop the apparatus by using the Hold/Release button. Subjects were not permitted to correct the angle [24,25]. Three trials were done and the angular difference mean of these trials, between the position of the predetermined angle and the perceived end range position of the subject (absolute error) was recorded in degrees as the deficit in repositioning accuracy and was used in the statistical analysis [26].

### Quadriceps strength:

The isokinetic device calibration was done in accordance with the specifications of the manufacturer. Muscle strength was obtained as the peak torque (PT), which represents the highest single torque output achieved by a muscle action through a range of motion. The subjects were seated at a 85 degree angle with the back support set. Straps were fixed horizontally and diagonally across the pelvis and the trunk, respectively. The lateral condyle of the femur was adjusted with the axis of the dynamometer's rotation. The force transducer cuff was aligned superior to the lateral malleoli. To make the patients familiarized with the device, they were informed about the protocol and performed three unloaded active repetitions ranging from maximal flexion to maximal extension. The range of motion was set at 90 degree. PT was determined with a set of three maximal repetitions at an angular speed of 60 degree/sec. During the test, the subjects were encouraged to perform to their maximum effort and received visual feedback through a monitor. The highest PT was measured in new tons per meter (N/m) [27].

## RESULTS

This study was conducted to evaluate the knee joint repositioning accuracy as a measure of knee joint proprioception and the quadriceps muscle strength between type II diabetic patients in early five years of the disease and normal subjects. Data were collected from the two groups and then analyzed. Descriptive and analytic statistics were used.

### I) General Characteristics of the Subjects:

Thirty male subjects participated in this study, 15 normal subjects and 15 patients with type II DM and they were assigned into two groups, the control group (A) and the study group (B)

#### Group (A):

This group included fifteen normal male subjects and the data in table (1) represented their mean age ( $44 \pm 6.49$ ) years, their mean weight ( $74.53 \pm 11.42$ ) kg and their mean height ( $169 \pm 4.88$ ) cm.

#### Group (B):

This group included fifteen male patients with type II DM and the data in table (1) represented their mean age ( $46 \pm 6.99$ ) years, their mean weight ( $81.4 \pm 15$ ) kg and their mean height ( $169.8 \pm 10.44$ ) cm.

Unpaired t test results between the groups showed no significant differences for age (where P value was 0.379), weight (where P value was 0.170) and height (where P value was 0.773) as seen in table (1).

**Table 1:** Physical characteristics of subjects in each group

Items	Group(A)		Group(B)		Comparison		S
	Mean	±SD	Mean	±SD	t-value	P-value	
Age (years)	44	±6.49	46	±6.99	0.893	0.379*	NS
Weight (Kg)	74.53	11.42	81.4	15	1.41	0.170*	NS
Height (cm)	169	4.88	169.8	10.44	0.291	0.773*	NS

\* $p \leq 0.05$

### II) Knee joint repositioning error:

Table (2) demonstrated the knee joint repositioning error for the two groups. The unpaired t-test revealed a non significant difference in knee joint repositioning errors between the control and study groups as the mean value of the control group (A) was ( $4.466 \pm 2.82$ ) and for the study group (B) was ( $5.38 \pm 2.048$ ) where the t-value was (1.014) and P-value was (0.319).

**Table 2:** Mean, SD, t and P values of Knee joint repositioning error between group A and B

Unpaired t test	Knee joint repositioning error	
	Control group (A)	Study group (B)
Mean	4.466	5.38
±SD	±2.82	±2.048
Mean difference	0.913	
DF	28	
t-value	1.014	
P-value	0.319*	
S	NS	

\* $p \leq 0.05$

### III) Quadriceps muscle strength:

Table (3) demonstrated the quadriceps muscle peak torque for both groups. The unpaired t-test revealed non significant difference in peak torque of the quadriceps muscle between the control and study groups as the mean value of the control group (A) was (165.04±40.55) and for the study group(B) was (144.57±36.34) where the t-value was (1.45) and P-value was (0.157).

**Table 3:** Mean, SD, t and P values of Quadriceps peak torque between group A and B

Unpaired t test	Quadriceps peak torque	
	Control group (A)	Study group (B)
Mean	165.04	144.57
±SD	±40.55	±36.34
Mean difference	20.46	
DF	28	
t-value	1.45	
P-value	0.157*	
S	NS	

\*p≤0.05

### DISCUSSION

This study was conducted to test the knee joint repositioning accuracy as a measure of knee joint proprioception and quadriceps muscle strength between type II diabetic patients in early five years of the disease and healthy subjects. Thirty male subjects participated in this study aging between 35 to 55 years old and they were assigned into 2 groups A and B, group A which was the control group included 15 normal subjects and group B which was the study group included 15 patients with type II DM (within the first five years of the disease) diagnosed by internal medicine physician.

Lephart et al., 1997, concluded that assessment by active joint reposition stimulates muscle and joint mechanoreceptors and is a more functional assessment of afferent pathways, and was proved to be a valid and reliable test for proprioception [28]. According to the results of this study there were mean differences between knee joint repositioning errors and quadriceps muscle strength for the control and study groups but these differences were statistically non-significant where p-values were (0.319) and (0.157) respectively. One of the explanations of these results is the duration of the disease as the patients were in the first five years of the type II DM where there were no major changes in the peripheral nerves which lead to peripheral neuropathy (polyneuropathy) or sensory deficits and affection of the proprioception sense and also there were no motor changes.

There is an agreement between this study and the study done by Sacco et al.,2005,who found that after ankle proprioception test, the results was approximately normal or near to normal in about 95% of DM patients with poly-

neuropathy, which means there is a slight involvement of the proprioception sense and this was explained by the gradual manner and behavior of diabetic polyneuropathy, which affects the distal part initially causing damage to the limbs, then spread proximally, and from small caliber non-myelinated nerve fibers to the large one with myelin sheath. According to the previous theory, proprioceptive sense would be the last characteristic to be affected among the somatosensory types, since this matches to the myelinated fibers. This could be the reason why the patients in our study didnot show much damage [29].

YoosefinejadandHaghighi., 2014, studied the difference between knee joint repositioning error for diabetic patients and healthy subjects and they reported a significant difference in knee joint repositioning error for diabetic patients. They concluded that DM patients especially those with polyneuropathy have impaired knee joint proprioception, which could make the patients vulnerable to fall and could lead to subsequent fractures and increased the level of morbidity and mortality<sup>21</sup>). It is also important that the afferent sensory inputs from the proprioceptive receptors and also the efferent motor nerves should be intact to maintain the balance [21]. The disagreement between our results and this result was mainly due to the effect of the polyneuropathy, which cause disturbance in the afferent sensory pathway.

Farzaneh et al., 2015,have also studied the difference between ankle joint repositioning error for diabetic patients and healthy subjects and they reported of a significant difference in ankle joint repositioning error for diabetic patients. They concluded that DM has the ability to disturb the balance and proprioceptive sensation in lower limb especially, in ankle joint which can put the patients with DM in risk of fall and further injury [30].

Regarding the isokinetic muscle strength in diabetes, muscle weakness associated with severe diabetic neuropathy has an uncommon manifestation. However, since the previous studies were cross-sectional in nature, it was indistinct whether decreased muscle strength in diabetes is a result of diabetes or just a concurrence [12]. The recent studies revealed decreased strength of the lower extremity skeletal muscle in adults with type II diabetes [17,20,21]. Andersen et al., 2004, reported that patients with long-term type I diabetes have impaired ankle and knee isokinetic muscle strength [20]. Also, it was concluded that type II diabetic patients with age less than 70 years old and a diabetes duration of more than 5 years have weakness in the ankle and knee muscles that was due to the severity of peripheral neuropathy [17].

The disagreement between our results and this result that showed decrease in the knee muscle strength in DM patients compared to normal subjects was due to the effect of the polyneuropathy that cause disturbance in the motor pathway. Moreover, long duration of disease may play a role in this situation. Park et al., 2006, found that assessment of the muscle strength of the leg muscles by using isokinetic

dynamometry in older adults aged 70–79 years with type II diabetes revealed a significant difference between type II diabetic older adults and non-diabetic older adults. However, the knee extensor strength of the type II diabetic older adults was lost more quickly than those without diabetes [17]. The disagreement between our results and this result may be due to functional and physiological changes of older adults due to aging.

Also Amin et al., 2014, reported that manual muscle test (MMT) of quadriceps muscle strength of type II diabetic patients associated with and without polyneuropathy has a weakness compared to healthy subjects. The results of this study revealed a significant difference between the patients with diabetes associated with neuropathy and those without neuropathy; there was also a significant difference between diabetic patients without neuropathy and the healthy subjects [21]. The disagreement between our results and this result may be due to the effect of the polyneuropathy on motor pathway and the different protocols of assessment used in both the studies.

## CONCLUSION

It was concluded that knee joint repositioning accuracy and quadriceps muscle strength aren't affected in early five years of type II diabetes mellitus. However it is recommended to conduct other studies to show the effect on distal muscles and to study the effect on different periods of diabetes.

## ACKNOWLEDGEMENT

We herewith express our sincere thanks to Mr. Eyad Jafar Ayash, Mr. Fuad Mamdooh Baik and Mr. Mohammad Abdulaziz Almadadi for their kind help during the work.

## Abbreviations used

DM- Diabetes Mellitus

N/M- Newton's per Meter

PN- Peripheral Neuropathy

PT- Peak Torque

WHO- World Health Organization

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#### **Citation**

Aboeleneen, A., & Darwesh, A. (2016). KNEE JOINT PROPRIOCEPTION AND QUADRICEPS MUSCLE STRENGTH AMONG DIABETIC AND NON DIABETIC SUBJECTS. *International Journal of Physiotherapy*, 3(6), 737-742.