Effect of Modulated Kilohertz Frequency Current on Quadriceps Muscle Activation in Subjects with Knee Osteoarthritis

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ABSTRACT

The current study was designed to investigate the effect of electrical stimulation of the quadriceps muscle using burst modulated kilohertz frequency alternating current (KAC) on quadriceps activation (QA) in subjects with knee osteoarthritis (OA) and to clarify whether there was correlation between QA and isometric quadriceps muscle strength, functional level and pain intensity. Sixty female patients with knee OA were divided into two equal groups. Control group (exercise group), received traditional exercise program and study group (electrical stimulation group), who received stimulation of quadriceps muscle using KAC in addition to traditional exercises. Assessment was conducted at the beginning of the study and after 3 months. Measurements included quadriceps central activation ratio (CAR), quadriceps maximum voluntary isometric torque (MVIT), pain intensity and functional level. Analysis of results revealed that electrical stimulation group recorded statistically significant improvements of CAR (P <0.000), and also statistically significant improvements of MVIT, pain intensity and functional level (P <0.000). While the exercise group, recorded non significant increase of CAR (P=0.1) and significant improvement only of MVIT (P <0.000), pain intensity (P <0.000) and functional level (P=0.003). Furthermore electrical stimulation group produced significantly better improvement of CAR (P=0.000), MVIT (P =0.000), and functional level (P =0.005) than the exercise group. There was non significant difference in pain intensity between both groups (P =0.3). There were significant correlations between CAR and muscle strength and functional level, while there was non significant correlation between CAR and pain intensity. This study demonstrated that QA should be considered when designing a rehabilitation program of patients with knee OA and that stimulation of quadriceps muscle using KAC could promote improvement of QA and strength with subsequent improvement of patient's functional level.

Key words: *kilohertz current, osteoarthritis, activation level.*

INTRODUCTION

Knee osteoarthritis (OA) is a common condition affecting synovial joints. It is characterized by pain and functional impairment including difficulty with several activities of daily living[6,10]. Weakness of the quadriceps muscle is well documented in subjects with knee OA[8,17] and it is strongly associated with pain and disability[20]. Multiple factors play a role in the etiology of muscle weakness. In addition to pain and disuse atrophy, the gradual decline in quadriceps strength associated with knee OA has been attributed, to impairment in the central nervous system's ability to fully volitionally activate the muscle (termed failure of voluntary activation or arthrogenous muscle inhibition (AMI)[8,11,17].

Arthrogenic muscle inhibition is an ongoing, reflex response leading to inability to completely contract a muscle despite no structural damage to the muscle or innervating nerve. This reflexive "shut-down" of a joint's surrounding musculature is initially protective. Unfortunately, AMI prevents complete activation of a muscle and, thus, may lead to muscle weakness[9]. Recently, it has been suggested that reduced quadriceps activation (QA) may have an impact on physical function in subjects with knee OA by moderating the relationship of quadriceps strength to function. Subjects with low strength and reduced QA had lower function than those with similar strength but high QA[5].

In rehabilitation of knee OA, quadriceps activation is an important factor to target because inhibited quadriceps muscles may lead to muscle weakness with subsequent increase joint stresses from decreased ability to attenuate loads across the joint[9]. So quadriceps inhibition prevent restoration of pre-injury quadriceps function, thereby become a limitation during rehabilitation of knee OA[2,9,27].

It has been strongly suggested that interventions specifically targeting AMI be used in rehabilitation of knee injuries. Restoring quadriceps function by removing neural inhibitory mechanisms may be essential in facilitating complete neuromuscular recovery[22]. Different forms of exercises have been reported to increased quadriceps strength along with improved pain and function, but strength deficits remain and overall effect sizes have been variable[3,7,26]. Few studies have suggested some improvement in QA with exercise alone, but results have been inconclusive. It was proposed that reduced QA might decreased the individual's capacity to produce enough tension in the muscle during exercise to achieve an exercise training effect, which in turn may limit their responsiveness to an exercise program[11,12,21]. This indicates the clinical importance of prescribing therapies aimed at removing AMI before rehabilitation exercises begin.

Neuromuscular electric stimulation using low frequency pulsed currents have been shown to improve quadriceps function and may be useful in patients experiencing posttraumatic AMI[18,23,28]. Two forms of electrical stimulation are commonly used clinically to augment muscle contractions, low frequency pulsed current (LPC) and kilohertz frequency alternating current (KAC) which is burst modulated at low frequencies[4,25].

The most well-known KAC used clinically for muscle strengthening is "Russian current" (RC), "Russian current" (RC), which is a 2.5-kHz sinusoidal alternating current applied at a burst frequency of 50 Hz and a burst duty cycle of 1:1. This current gained popularity following its introduction in 1977 by the Russian scientist Kots, who claimed that it produced muscle strength gains of up to 40% in athletes[31]. Burst-modulated alternating current stimulation is claimed to be comfortable and capable of eliciting greater muscle torque. KAC was suggested to result in summation and multiple firing of motor units which leads to synchronous firing of all motor unites with subsequent increase in force production[29,32].

Despite the presence of number of studies investigating the effect of KAC on healthy subjects with promising results, to the best of our knowledge, no one study has investigated the effect of the KAC on patient populations with AMI. So the current study was conducted (1) to investigate the training effect of KAC on QA in subjects with knee OA. (2) to determine the impact of QA on quadriceps muscle strength and functional level.

MATERIALS AND METHODS

Subjects

This is a randomized controlled single blind study in which 60 females with unilateral chronic knee OA were recruited from the Outpatient clinic of Faculty of Physical Therapy, Cairo University. Their mean age were (42±4.1 years) height (168±5.4 cm), and weight (83.2±3.7 Kg). Diagnosis of OA was confirmed by an orthopedist based on the American College of Rheumatology clinical and radiological classification criteria. Participants with OA were included if they had grade II OA with knee pain, had demonstrated osteophytes and definite joint space narrowing based on X-ray[1]. All participants were independent in activities of daily living. Patients were excluded from the study if they had undergone total knee arthroplasty, exhibited uncontrolled hypertension and had history of cardiovascular disease or neurological disorders that affect lower extremity function or use assistive devices for walking. All patients were refrained from seeking other forms of treatment during the study, other than a stable dose of non steroidal anti-inflammatory drug equivalent to 300 mg aspirin[6].

Patients were randomized into two equal groups. Control group receive exercise program and study group received KAC in addition to exercise. Randomization was achieved using the one to one randomization method by allocating patient according to their arrival to the outpatient clinic, one patient to the study group and the other patient to the control group one by one. Also the patients were blinded about the group.

Testing procedure

Assessments were conducted at baseline and after completion of the physical interventions months of exercise and electrical stimulation by an assessor who was blinded to group allocation. Assessment included quadriceps activation ratio (CAR), quadriceps maximal voluntary isometric torque (MVIT), functional level and pain intensity.

Quadriceps maximal voluntary isometric torque (MVIT)

The assessment was conducted at the Isokinetic Lab, Faculty of Physical therapy, Cairo University. Biodex 3 Pro multijoint Isokinetic dynamometer to was used to measure quadriceps isometric torque. Each patient was informed about the steps of the test procedures and the apparatus was calibrated according to the manufacture manual. The subject was seated with the tested limb at hip 120 degrees flexion and knee at 60 degrees flexion. The subject back, thigh, and leg were stabilized by the system pads and belts. The fulcrum of the lever arm was aligned with the lateral epicondyle of femur and the inferior portion of the shin pad was adjusted at 5 cm superior to the right medial malleolus. The subject performed three trials of 5 seconds maximum voluntary isometric contraction with 1-minute rest between trials. The subject was asked to maximally extend the knee joint while verbal encouragement was done. The MVIT was recorded and averaged in Newton-meters (Nm) for the three trials. Muscle torque was reported to be valid method for evaluation of muscle strength capacity [15].

Measurement of quadriceps activation

The magnitude of QA was measured using a burst-superimposition maximum isometric quadriceps torque (SIBT) test. This procedure has been shown to yield reliable quadriceps muscle activation measurements[16]. Measurement of QA was performed at the same session, after measurement of quadriceps MVIT using the Biodex 3 Pro multijoint Isokinetic dynamometer. Superimposed electrical stimuli of the quadriceps were delivered using an electrical stimulator (Phyaction 790). Two Electrodes were placed one proximally over the vastus lateralis muscle belly and the other distally over the vastus medialis muscle belly. Subjects were asked to exert as much force as possible while extending the knee against the fixed force arm of the dynamometer and to hold each maximal contraction for 3–5 seconds. During the maximal contraction the train of electrical stimuli (amplitude = 100V or 130V, pulse duration = 600 µsec, pulse interval = 10 msec, train duration = 100 msec) was applied to determine the extent of muscle activation. To maximize their ability to produce maximum torque output during the test, the examiner provided intense verbal encouragement to subjects and provided with real time visual feedback of the torque trace displayed on a computer monitor. Each subjects completed 3–6 trials with 1 ½ minutes of rest between trials until the level of torque produced decreased compared to the prior trials.

The magnitude of QA was calculated using the quadriceps central activation ratio (CAR), which is a ratio of the highest maximum voluntary torque produced prior to delivery of the electrical stimulus divided by the highest torque produced when the electrical stimulus was superimposed on the maximum voluntary contraction. According to the following equation: CAR = MVIT/ MVIT+SIBT.

Full QA is represented by a CAR equal to 1 as the superimposed electrical stimulus does not result in a further increase in torque compared to the maximum voluntary torque. When failure of full QA is present CAR is less than 1. That because the electrical stimulus will recruit previously inactive muscle fibers to fire and the torque produced with the superimposed electrical stimulus will surpass that of the maximum voluntary torque[5].

Measurement of Pain intensity

Visual numerical scale (VNS) was used to determine the degree of perceived pain. The subject was asked to choose a number between 0 to 10 in 1 cm chart with 0 indicated no pain and 10 unbearable pain. The subject marked the number corresponded to the pain intensity[24].

Functional Level

The functional level of the patients was assessed by the arthritis impact functional assessment scale (AIFAS). The validity and the repeatability of this scale have been demonstrated[19]. This scale the level of function in five subscales including pain, walking distance, walking aids, standing and climbing stairs. Patients was asked to rate their pain and ability to perform various ADL, scoring between 0 and 24 points. Lower scores indicate better subjective functional abilities.

Exercise therapy

Standard exercise therapy program consisted of lower extremity stretching, and range of motion and strengthening exercises. The exercises were done three days a week at alternate day for three months with a total of 36 sessions. The exercise program was carried according to the following protocol[3]:

- Range of motion and stretching exercises applied to calf muscle and hamstring muscle. With a dose of three repetitions, each of 30 seconds duration with a rest period of two seconds.
- Isometric exercises of quadriceps and hamstring muscles and the abductor and adductor muscles of the hip applied for six second with eight repetitions and a rest period of four seconds.
- Isotonic resisted exercises of quadriceps and hamstring muscle. First, the maximum weight that can be lifted 10 times (10 repetition maximum) was determined and the exercises were conducted as 10 repetitions with half of this weight, then three fourths of this weight, and finally the whole weight. 10 repetition maximum was determined again every two weeks.

Electrical stimulation

Using an electrical stimulator (Phyaction 790), electrical stimulation of the quadriceps muscle was delivered three days a week at alternate day for three months with a total of 36 sessions. For each subject, the area of electrode placements of the treated thigh was cleaned with alcohol. Two standard carbonized rubber electrodes of equal size (5x10.5 cm) with sponge pads soaked in tap water were used to stimulate the quadriceps muscle. One electrode was placed over the motor point of vastus medialis and the other electrode was placed over the motor point of vastus lateralis. In an attempt to ensure identical electrode placement for subsequent testing trials, the electrodes sites were traced onto a clear transparency[18]. The quadriceps then was stimulated using modulated KAC current with the following parameters. Current frequency2500Hz, burst frequency 20, burst duty cycle 1:4 (20%), phase duration 200μs, burst/interburst duration 10/40ms, cycles per burst 25, and cycles per second 500. The duration of the current application was 30 minutes[29,31,32].

Data Analysis

The variables that have been under investigation were Quadriceps CAR MVIT, pain intensity, and AIFAS scores. Statistical analysis was performed using "SPSS" for windows evaluation version 15.0. Data were presented as mean and standard deviation (SD). Differences between and within groups were assessed using student t-test. The degree of association between QA and other measured parameters were estimated using Pearson correlation. Significance level was set at (0.05).

RESULTS

There were no significant differences between both groups with respect to age, body weight, or height (P> 0.05) as shown in table (1).

Table (1): Characteristics of the patients in both groups.

	Age (Years)		Weight (Kg)		Height (Cm)	
	Study	Control	Study	control	Study	control
Mean	40.8	43.2	84.5	81.9	166.7	169.7
SD	2.4	1.7	2.3	1.4	3.1	2.3
t	1.56		1.08		0.42	
P	0.1		0.29		0.67	

Quadriceps Activation

As shown in table (2), Regarding changes in the quadriceps CAR in the study group receiving electrical stimulation and exercises, there was statistically significant improvements when comparing pre and post results (P < 0.000). While there was no statistically significant change of the quadriceps CAR in the control group trained with exercise alone (P=0.1).

When comparing the values of CAR of both groups, there were no significant differences at pre exercises values (P = 0.3), while at post measurement there was significant increase of the quadriceps CAR in the study group than control group (P < 0.000), table (3).

Table (2): Comparison of measured parameters at pre and post treatment in both control and study groups.

Measured parameters	Control		Study	
	Pre	Post	Pre	Post
	Mean± SD	Mean± SD	Mean± SD	Mean± SD
CAR	74.3 ± 4.5	78 ± 3.44	76.1± 2.6	90 ± 0.3
	t = 1.5, P= 0.1		t = 10.9, P < 0.000*	
MVIT	139.2 ± 16.6	151.2 ± 13.05	138.2 ± 12.7	165.5 ± 12.6
	t = 11.5, P< 0.000*		t = 13.5, P < 0.000*	
Pain intensity	7.9 ± 1.54	4.7 ± 1.2	7.4± 1.8	5.1 ± 1.6
	t = 9.5, P< 0.000*		t = 10.8, P < 0.000*	
AIFAS scores	17.2 ± 2.4	14.9 ± 0.47	17.1 ± 1.3	10.6 ± 0.69
	t = 3.2, P = 0.003*		t = 7.8, P < 0.000*	

CAR: central activation ratio, MVIT: maximum voluntary isometric torque, AIFAS: arthritis impact functional assessment scale, *: significant.

Quadriceps MVIT

In both groups, statistically significant improvements were obtained in quadriceps MVIT at post treatment compared with pre treatment (P < 0.000), table (2). On comparison of the two groups with each other, there was non significant difference at pre treatment. But at post treatment measurement, study group recorded significant higher torques than control group (P< 0.000), table (3).

Pain-intensity level

As demonstrated in table (2) both groups recorded significant decrease of pain intensity when comparing pain degree at baseline with post measurement (P < 0.000). There was no statistically significant difference between the two groups at baseline (P= 0.2) and post treatment (P =0.3) table (3).

Functional level

In both groups, improvement of functional level was established as presented in the significant decrease of AIFAS scores at post intervention compared with baseline values (P= 0.003 and P < 0.000) for control and study group respectively, table (2). When comparing both groups, there was non significant difference at pre measurement (P= 0.73) and significant improvement of study group at post measurement compared to that of control group (P= 0.005) table (3).

Table (3): Comparison between control and study groups at pre and post measurement.

Measured parameters	Pre		Post	
	t	P	t	P
CAR	1.21	0.3	22.4	0.000*
MVIT	1.27	0.2	7.4	0.000*
Pain intensity	1.28	0.2	1.1	0.3
AIFAS scores	0.34	0.73	2.8	0.005*

CAR: central activation ratio, MVIT: maximum voluntary isometric torque, AIFAS: arthritis impact functional assessment scale,*: significant

Correlation of quadriceps CAR and tested parameters

At baseline, and at post intervention, significant direct associations were observed between quadriceps CAR and quadriceps MVIT. Also significant indirect correlations were observed between quadriceps CAR and AIFAS scores. In the other hand, there was non significant correlation between quadriceps CAR and pain intensity reported by the patients, table (4).

Table (4): Correlation between quadriceps CAR and the other tested variables.

Balance measures	Baseline		Post intervention	
	r	P	r	P
MVIT	0.6	0.001*	0.8	0.001*
Pain intensity	-0.27	0.07	-0.45	0.2
AIFAS scores	- 0.8	0.0001*	-0.8	0.0001*

MVIT: maximum voluntary isometric torque, AIFAS: arthritis impact functional assessment scale, *: significant

DISCUSSION

Neuromuscular electrical stimulation was reported to be efficient in increasing muscle strength and highly recommended in conditions where voluntary contraction is inhibited[4,18,23,25,28]. Yet data are lacking to establish the efficacy of KAC in subjects with chronic knee OA. The current study was designed to investigate whether KAC is capable of improving quadriceps muscle activation in subjects with knee OA.

The results of the current study showed that training with KAC for three months leads to significant improvement of the QA with subsequent increase of quadriceps strength, decrease in pain intensity and upgrading of the functional activity level. A likely explanation of the results is that when bursts of KAC are used, successive pulses within a burst can summate, with each pulse pushing the nerve fiber membrane closer to threshold until an action potential is produced. If the bursts are long enough, fibers could fire at some multiple of the burst frequency[29,30].

It was suggests that Strategic implementation of treatments aimed at improving QA may be an appropriate strategy to overcome persistent postinjury muscle weakness. Individuals without activation deficits were reported to have greater success in strengthening the quadriceps[22]. Furthermore stronger quadriceps has been linked to greater functional ability and a reduction in symptoms[20].

In the current study, we did not use traditional Russian current with the 50% burst duty cycle, but we used KAC with low burst duty cycle of 20 %. It was reported that when using Russian current with typical burst duty cycle, muscle fatigue may result. In the other hand, when strength, comfort and fatigue were considered KAC with low burst duty cycle was preferred[29,32].

The finding of the present work showed that traditional exercise alone failed to produce significant improvement of QA despite the significant increase of muscle strength and significant improvement of functional level with reduction of pain intensity. It was postulated that a lack of motivation, pain in the knee joint, or fear of producing further pain with a maximal contraction, reduces the central nervous system's input to the α-motorneuron pool and results in impaired ability to respond effectively to exercise. It is possible that the presence of reduced QA could contribute to this lack of robust response[11].

The present study also presented that patients trained with both burst modulated KAC and exercises recorded higher quadriceps muscle activation and strength with better functional level than patients trained with exercises alone. So these data clearly establish that if patients with symptomatic knee OA are provided with appropriate method to decrease quadriceps activation deficits, the patient response to exercise might be intensified. In accordance to that, it was reported that an important underlying factor contributing to persistent rehabilitation-resistant posttraumatic quadriceps weakness is AMI[9,27].

In management of knee OA we should be aware of this clinical dilemma and focus rehabilitation interventions on promoting QA, thereby providing patients the benefit of exercising with a more complete motor neuron pool. It was reported that QA failure in anterior cruciate ligament deficits patients remained unchanged after 4 weeks of traditional strengthening[13]. This indicates the clinical importance of prescribing therapies aimed at increasing QA before rehabilitation exercises begin.

Therefore, the results of this study have important clinical implications for the rehabilitation of patients with knee osteoarthritis. If activation deficits of the quadriceps could be eradicated through in patients with knee osteoarthritis, then there is reason to believe that using KAC can influence the patient's function.

In the current study, the burst superimposition technique was used to measure the quadriceps muscle activation level through determining the CAR. There are two techniques for determining the voluntary activation failure, which are the twitch interpolation and the burst superimposition techniques, both of which superimpose an electrical stimulus on a volitional muscle contraction. The underlying premise of both techniques is that if the muscle is not maximally activated, the electrical stimulus would be capable of generating additional force above that of the volitional force. Volitional muscle force increases as a result of increases in discharge rate and increases in motor unit recruitment. Greater recruitment leaves fewer inactive motor units to be stimulated by the superimposed electrical stimulus, which would yield a smaller electrically induced force during the stimulation. When all available motor units are volitionally activated, no augmentation in muscle force should be elicited by the electrical stimulus. Both protocols have been shown to be highly reliable and reproducible in subjects with knee injuries and knee OA[5,16].

The finding of the study demonstrated significant relation between QA and both quadriceps strength and functional level of the patients. Consistent with our results, prior research, found that lower QA is associated with lower quadriceps strength [10]. Quadriceps activation failure after knee joint injury was suggested to correlate with the persistent weakness of the quadriceps and so to limit effects of the rehabilitation program which compromise the subject's functional ability[5,8,17].

The present finding showed that there was non significant difference of pain intensity between both groups at post measurements furthermore there was non significant association between QA and pain intensity. This indicate that the decrease in pain intensity was mainly due to the effect of exercise as reported by other authors[3,21,26]. In other wards, it could be suggested that QA is not dependent on pain which might explain the results of the exercise group which showed non significant improvement of QA despite significant decrease of pain intensity.

Conclusion

From this study, it might be concluded that electrical stimulation of the quadriceps using burst modulated KAC could be useful in improving quadriceps activation level which might result in higher functional level of subjects with knee OA. Further studies comparing the effect of low frequency currents and burst modulated KAC are needed.

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الملخص العربي

تأثير التيار المعدل ذو تردد الكيلوهيرتز المتغير على تنشيط عضله الفخذ الرباعية الاماميه فى الأشخاص المصابون بالتهاب مفصل الركبه

أجريت هذه الدراسة لدراسة تأثير التنبيه الكهربائى لعضلة الفخذ الرباعية الاماميه باستخدام التيار المعدل ذو تردد الكيلوهيرتز المتغير على تنشيط عضله الفخذ الرباعية الاماميه فى الأشخاص المصابون بالتهاب مفصل الركبه ولتوضيح ما اذا كانت هناك علاقه بين نشاط عضله الفخذ الرباعية الاماميه و كل من قوة عضله الفخذ الرباعية الاماميه ومستوى الآداء الوظيفى وشدة الألم . أجريت هذه الدراسة على ستون مريضه بالتهاب مفصل الركبه تم تقسيمهم الى مجموعتين متساويتين . المجموعه الضابطه (مجموعة التمارين) تلقت برنامج من التمارين التقليدية ومجموعه الدراسه (مجموعة التنبيه الكهربائى) تلقت برنامج من التنبيه الكهربائى لعضلة الفخذ الرباعية الاماميه باستخدام التيار المعدل ذو تردد الكيلوهيرتز المتغير بالاضافه الى التمارين التقليدية. تم تقييم الحالات فى بداية الدرسه وبعد ثلاثة أشهر من العلاج. اشتملت القياسات على معدل تنشيط عضله الفخذ الرباعية الاماميه ، أقصى عزم لى إرادى ايسوميترى لعضله الفخذ الرباعية الاماميه ، شدة الألم ومستوى الآداء الوظيفى. أثبتت المعالجه الإحصائية للنتائج أن مجموعة التنبيه الكهربائى سجلت تحسن ذو دلالة إحصائية فى معدل نشاط عضله الفخذ الرباعية الاماميه (P <0.000) وكذلك تحسن ذو دلالة إحصائية فى أقصى عزم لى إرادى ايسوميترى لعضله الفخذ الرباعية الاماميه و شدة الألم ومستوى الآداء الوظيفى (P <0.000). بينما سجلت مجموعة التمارين زيادة ليست ذات دلالة إحصائية فى معدل نشاط عضله الفخذ الرباعية الاماميه (P =0.1) و زيادة ذات دلالة إحصائية فقط فى أقصى عزم لى إرادى ايسوميترى لعضله الفخذ الاماميه الرباعية (P <0.000) وشدة الألم (P <0.000) ومستوى الآداء الوظيفى (P =0.003). بالأضافه الى ذلك تبين وجود تحسن ذو دلالة إحصائية في مجموعة التنبيه الكهربائى عنه في مجموعه التمارين بالنسبه الى معدل نشاط عضله الفخذ الرباعية الامامية و(P =0.000) ، أقصى عزم لى إرادى ايسوميترى لعضله الفخذ الرباعية الاماميه (P=0.000) ومستوى الآداء الوظيفى (P =0.005). ووجد اختلاف ليس ذو دلالة إحصائية بين المجموعتين بالنسبه لشدة الألم (P =0.3). وجدت علاقة ذات دلالة إحصائية قوية بين تنشيط عضله الفخذ الرباعية الاماميه و كل من قوة عضله الفخذ الرباعية الاماميه و مستوى الآداء الوظيفى بينما لم توجد علاقة ذات دلالة إحصائية بين نشاط عضله الفخذ الرباعية الاماميه وشدة الألم. أثبتت هذه الدراسة ان مستوى تنشيط عضله الفخذ الرباعية الاماميه يجب أن يوضع فى الاعتبار عند تصميم برنامج تأهيل لمرضى التهاب مفصل الركبه وان تنبيه عضله الفخذ الرباعية الاماميه باستخدام التيار المعدل ذو تردد الكيلوهيرتز المتغير يمكن ان يحدث تحسن فى نشاط عضله الفخذ الرباعية الاماميه وما ينتج عنه من تحسن فى مستوى الآداء الوظيفى للمريض.