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INFLUNCE OF ELECTRO-MYOSCOPE(ACUSCOPE) ON INJURED QUADRICEPS FEMORIS WITH USING ELECTRO_MYOGRAPHIC ANALYSIS BUILT INTO THE ELCETROMYOSCOPE

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- ABSTRACT -

이 실험의 목적은 Electro-Myoscope 이 과다 사용에 의해 일어나는 대퇴사두 근육 통증에 미치는 효과에 대해 근전도를 이용한 연구입니다. 이를 위해 나이 15세부터 50세 사이의 18명의 여성 자원자들이 참여했다. 대퇴직근을 Cybex 운동기기를 사용해 Terminal knee extension 운동을 통해 과다사용으로 인한 통증이 유발되게 하였다. 그리고, Electro-Myoscope을 치료 후 근전도를 통해 대퇴사두근의 motor recruit 에 대해 기록 비교하였다. t-test 와 Chi square 분석 결과 대퇴사두근의 기능이 향상된 것으로 나타났다.

The purpose of this study was to evaluate the effectiveness of ElectroMyoscope(Electro_Acuscope and Myopulse) in tissue repairing on fatigue quadriceps femoris(rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis).

Subjects were female adult volunteers with (n=13) and without (n=5) chronic fatigue muscle pain. We needed to fatigue the rectus femoris by overusing of a Cybex machine exercise. We turned the Electro-Myoscope to treatment mode and treated with treatment probe on the fatigue muscle, then turned instrument back to EMG and took the reading. The results indicated that the reading after the treatment was lower than before the treatment. A two-tailed t-test and Chi square indicated significant results($P<.03$). It appears that the Electro-Myoscope is effective in treatment on the fatigue muscle.

Key Words : EMG, Electro-Myoscope, Terminal knee extension

INTRODUCTION

CLINICAL ANATPMY AND MECHANICS OF THE QUADRICEPS FEMORIS:

The qudriceps femoris: consists of four muscles(rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius). This great extensor muscle of the leg covers the anterior and lateral parts of the femur

origins: Anterior inferior iliac spine and groove superior to acetabulum(rectus femoris), greater trochanter and lateral lip of linea aspera of femur (vastus lateralis), intertrochanteric line and medial lip of linea aspera of femur(vastus medials), and anterior and lateral surfaces of body of femur (vastus intermedius).

Insertion: Base of patella and via patellar ligament into tibial tuberosity

The quadriceps tendon is inserted into the patella. This common tendon continues inferiorly as the patellar ligament or ligamentum patellae which inserts into the tibial tuberosity.In addition, expansions of the aponeruoses of the vasti muscles, called the medial and lateral retinacula of the patella, insert into the condyles of the tibia. (More, Clinically Oriented Anatomy p419)

Nerve supply: All four components of the quadriceps femoris muscle are supplied by the femoral nerve(L2, L3, and L4).

Actions: quadriceps femoris extend leg at knee joint. All four parts of the quadriceps contributes to this action by pulling on the patella and through it the patellar liganemt extends the leg at the knee joint. Only one part of the quadriceps(rectus femoris) crosses the hip joint, thus the rectus femoris also flexes the hip. Quadriceps femoris is used during climbing, running, jumping, and rising from a chair.

BIOELECTRICAL SYSTEM

The most important information processing mechanism in the living cell is the neural network. Neuro-functions are chemical in nature which is developed by single cell or collectively by groups of cells. These neuro-functions are also producing changes in the electric field which can be monitored by electrodes. Direct measurements of the chemical phenonema, e.g., ion concentration changes, can be performed by means of special transducers(ion selective electrodes). Electroencephalographic(EEG), electrocardiographic(ECG), electromyographic(EMG), and other such signals are routinely used for the diagnosis of neural and muscular system in the clinic.

The source of the bioelectric signal in the songle neural or muscular cell. These do not function alone but in large groups. The basic processing unit in neuro-function is the nerve cell, the Neuron. Its function is information processing, transfer, and acquisition. The cell body consists of the intracellular fluid with the various bodies required for the functioning of a cell.

information into neuron from other neuron is introduced through a junction called synapse. Synapse are located on the dendrites or on the soma. The synapses can cause an increase or decrease of the voltage across the membrane. The cell function is based on the intergrative(in time and space) effects of these potential changes. Nerve and muscle cells have excitable membranes which have different permeability th the various ions in the solutions. As a result of ions transfer, cell diffusion, electric field os generated across the membrane.

Electrical current is simply the rate at which electrical charge is passing a given point along a wire conductor, of is passing through a designated area in a volume conductor at some point in time. Current is passing along an electrode wire. If this current, at a certain instant in time, is passing along an electrode wire, the same value of current passes through the eletrode into the straum corneum of the skin and through the volume conductor of the tissue to the other electrode, to return to the electrotherapeutic instrument which produces the pulse, thus completing the circuit.

THE FUNCTION OF ELECTRO-MYOSCOPE:

Electro-Acuscope: The Electro-Acuscope is an electrotherapeutic instrument which acts upon subcutaneuos tissues to reduce pain and inflammation. It will improve blood flow in circulatory-impaired tissues.

Many types of tissues cells have membranes with ions channels that are voltage-sensitive.

Electrotherapeutic currents can increases the entrance of substances such as calcium ions which turn on repair mechanisms within those cells. Sensory nerve endings, for instance, release vasoactive peptides in response to the entrance of calcium. The Electro-Acuscpoe monitors the electrical conductivity and impedance of the tissue, and also can compute important electrical characteristics of the tissue from the current and voltage pulses themselves. Using this information, it adjusts the shape of those current and voltage pulses in order to optimize treatment effectiveness. The output pulses of the Electro-Acuscope are neither constant current nor constant voltage during their duration, but are between the two modality limits.

Myopulse: The Myopulse instrument is designed to treat connective tissue associated primarily with muscle. The amplitudes of the current and voltage pulses continuously vary within a "sinusoida modulation envelop." It is well established that the membrane of each muscle fiber contains voltage-controlled calcium ion channels.

Much of the effectiveness of the Myopulse instrument appears to be due to modest increases in internal calcium which, though inadequate to cause muscle contraction, could still result in increased ATP and protein synthesis in order to prevent atrophy, accelerate tissue repair and alleviate pain. (It would not be desirable to induce muscle contraction in the manner of conventional muscle stimulator, because this would use up ATP which could be put to better use as energy source for synthesizing new cellular repair molecules.) Since the current and voltage pulses have constantly varying amplitudes over the four second period of each modulation envelop cycle, some impulses will be optimal for each portion of the three dimensional current field(even to considerable depth into the tissue). Some of the current pulses will have an initial current overshoot portion that can open higher threshold ion channels especially in regions of the current field that are closer to the electrodes. In addition to monitoring the current waveform of each pulse, the Myopulse instrument also has special current and voltage monitoring impulses to provide tissue impedance information.(Electro-Medical, INC.)

LITERATURE REVIEW:

Electromyographic analysis of knee muscles: Dr. Ciccotti designed testing on Electromyographic analysis of the knee during functional activities. Twenty-two healthy subjects volunteered to participate in the study. Each subject had fine-wire electrmyographic evaluation of 8 muscle(vastus medialis oblique, vastus lateralis, rectus femoris, semimembranosis, biceps femoris, tibialis anterior, gastrolcnemius, and soleus muscles)while performing 7 functional activities. Fine-wire EMG allowed accurate measurement of individual muscle activity as well as identified the firing patterns and intensity of contraction. The vastus medialis oblique showed the highest activity followed by vastus lateralis and rectus femoris muscle especially during early stance.(American Journal of sport Medicine, 1994)

Another study was also done, the Electromyographic analysis of knee musculature, during running by William Montgomery Ⅲ, M.D., Marilyn Pink, MS, PT, and Jacqueline Perry, M.D..

By studying the biomechanics of running one may offer insights to injury prevention, I have reviewed especially on the knee extensors, quadriceps muscles. The major period of activity was during early stance like the study was shown by Dr. Ciccotti. During peak activity, the three vasti had significantly greater activity than the rectus femoris muscle, and the vastus medialis was significantly greater than the vastus intermedius muscle.(The American journal Sports Medicine, 1994)

There were also few studies done to compare EMG data obtained from the knee muscles durning the four different exercises, straight leg raise, short-arc knee extension, squat, and short-arc knee extension with hamstring contraction. From Dr. Gryzlo's study I have found that the vastus medialis oblique had significantly more activity(56%)during the 15-0 degree knee extension than during other exercises. The vastus lateralis was the same, demonstrating significantly more activity during the 15-0 degree knee extension(58%)than the other exercise(27% and 14%)(JOSPT, 1994). Dr. Soderberg and Dr. Minor, et, al, performed the research on Electromyographic analysis of knee exercises in healthy subjects and in patient with knee pathologies. This was designed 세 compare electromyographic data obtained from the quads, gluteus medius, and biceps femoris muscles during maximally resisted straight-leg-raise with EMG data obtained from the same muscles during quadriceps femoris muscle setting(Q) exercises in healthy subjects and in patients with knee pathologies. Review of data shows that the quadriceps femoris muscles produced lower percentages of maximal EMG values in this study, whereas the other two muscles studied showed increased levels of activity.(Physical Therapy. Nov, 1994)

Accelerated tissue repair with Electro therapy: Feedar, Kloth, and Gentzkow have shown that electrical stimulation enhances the rate and extent of healing of chronic wounds. Their findings are also in accord with those of investigations demonstration that electrical stimulation can be used to promote healing of acute wounds induced in animals and to prevent necrosis from developing in ischemic skin flaps in humans. (Physical Therapy, 1991)

Dr. Reed studied on effect of High Voltage Pulsed Electrical Stimulation on microvascular permeability to plasma proteins which was a possible mechanism in managing edema (Physical Therapy. 1988). The purpose of this study was to determine whether high boltage pulsed electrical stimulation reduces microvascular permeability to plasma proteins in a simulation of acute edema. He found that HVS reduced microvessel permeability to plasma macromolecules in the histamine-superfused hamster cheek-pounch and retarded edema formation in acute inflammation.

Some clinician think that the wave form of a current pulse(Which can be determined by connection an oscilloscope across a small resistor in series with one of the wired leading to the electrodes)is not applicable to a consideration of the physiology process which is occurring within the tissue. Paul Dreyfuss, MD, and Steve Stratton, Phd, PT, wrote the article "The Low-Energy lager, Electro-Acuscope, and Neuroprobe: treatment Options remain controversial."(The Physician and Sports Medicine . August 1993) According to the article:" A current of less than 500 microA is recommended; research on electric currents has shown inhibited cell growth and tissue repair, decreased ATP concentration, reduced protein synthesis, and decreased transfer of ions across cell membranes at higher currents."

Other research which has been done by Cheng N. Van hoof H, and Bockx E. et. al, showed that direct currents ranging from 10 microA to 1,000 microA increase ATP concentration in the tissue and stimulate amino acid incorporation into the proteins of rat skin. The amino acid transfer through the cell membrane, followed by a-aminoisobutyric acid uptake, is stimulated between 100 microA and 750 microA. The stimulatory effects on ATP production and on amino acid transport, apparently mediated by different mechanisms, contribute to the final increased protein synthesizing activity.(Clin Oratho, Nov-Dec, 1982)

A case study reported by Stephen Center MD suggested that the Electro-Acuscope treatment to Achilles tendon's pain was very effective. The 15 year old female with complaining of Achilles tendon pain bilaterally, worse on the right, associated with bilateral hip joint and anterior iliac crest is a member of her high school track team, competition in one to two mile races and running cross country race. She received the Electro-Acuscope treatment to bilateral ankles and the right thigh with total seven treatments. She was entirely asymptomatic and discharged.

The Electro-Acuscope monitors the electrical impedance of the tissue and adjusts the output wave form to optimize the treatment current. When the direct current tissue resistance is lower than normal(as would be expected when the insulted tissue is characterized by a disruption of its extracellular matrix), the width of the current overshoot portion of the pulse increases(to 200 msec or more on the highest current setting). This will purposely open more calcium channels on the sensory neuron that release the neuroactive and vasoactive peptides(Electro-Medical INC. Fountain, Ca.). The Electro-Acuscope therapy provides a viable alternative. A homeostasis is created in the autonomic nervous system that allows lymphatic congestion and blockage to be relieved. Therefore, trapped protein clusters are broken up and unobstructed lymphatic flow is re-established which can promote the healing wounds and injured muscles.

METHODS

This study was conducted in the laboratory Electro-Medical INC. at Fountain Valley, CA. Eighteen healthy female volunteered subjects for participation in the study with ages ranging from 18 to 50 years. none of the subjects had a history of knee or hip injury. They all had a full range of motion, and no atrophy of the lower extremity muscles was present.

To record the myoelectric activity the chin of the tested quadriceps femoris was cleaned with alcohol-soaked gauze. The electro-pads, 1x1 cm each, for the rectus femoris muscle were placed one half of the distance from the anterior superior iliac spine to the superior pole of the patella and the anterior superior iliac spine. Conductive gel was put on the electro-pad sites.

To begin the testing, the subject overuser the Cybex machine doing 40 reps of short-arc knee extension exercise in sitting position with 30lbs weight to fatigue the rectus femoris. The first EMG reading was taken from the fatigued rectus femoris, then followed by the treatment with Myoscope. The second ENG reading was taken at this point without doing any muscle activities.

Instrument: Electro-Acuscope and Myopulse were used to treat the fatigued muscle with intensity at 100-300 microA, frequency at 20-80 Hz, and duration 15 minutes. Electromyography, which was built in with Electro-Myoscope, was used to record.

The spec's of the EMG are:

Band 1 1-10 microvolts

band 2 10-100 microvolts

Common Mode Rejection 1 million to 1

Pass band 65 Hz to 400 minus 3 Db(decibels)to 12Db rolloff

Internal noise is less than 2 microvolts RMS with 20,000 ohms source impedance

Direct microvolt reading

RESULTS

The mean height, weight, and age of the subjects are presented Table 1. Both groups reported good to excellent health and light to vigorous regular exercise. The duration of pain was over one year in all pain subjects although the mechanism of injury varied including lifting injury, sports injury, motor vehicle accident, and idiopathic. The mean pain intensity was 2.2 (SD=2.4), and the location of the pain varied with having pain primarily on the left side, 4 on the right side and 6 bilaterally.

Table 1. Characteristics of subjects with and without pain.

	pain	no pain
	n=13	n=5
	Mean(SD)	Mean(SD)
Height	66 (3.3)	66 (1.5)
Weight	145 (37.3)	131 (8.9)
Age	40 (13.7)	45 (5.0)

Only the last repetition of abduction with 10 pounds was statistically analyzed for this study due to the large amount of data collected and the unavailability of computerized technology to assist in data analysis at this time. This variable was selected based upon visual observation of the variations in EMG activity. Variations between the pain and no pain groups appeared most obvious during terminal knee extension exercise.

All EMG activity measurements were standardized by dividing by the peak EMG activity obtained from MMT, thus obtaining a percentage of the maximum EMG activity. This was done to account for individual variation in subcutaneous fat and skin impedance.

The shape of the curve was examined by measuring ROM at the time that peak EMG activity occurred during terminal knee extension. This was compared to the EMG activity at the end of the range at full extension of the knee. In some subjects there was a marked decline in muscle activity from the mid range the end range(fig. 1), whereas others continued steadily increasing reaching a peak in activity near the end of the range(fig. 2).

Peak EMG activity of the Quadriceps occurred earlier in the range for the pain group. In the right Lower extremity the mean ROM at peak Quad EMG activity was 85 degrees (SD=52.3) in the pain group and 145 degrees (SD=36.5) in the no pain group (Table 2). Using an independent t-test this difference was statistically significant(P=.03). The left Lower extremity mean ROM at peak Quadriceps activity was 73 degrees (SD=60.4) for the pain group and 118 degrees (SD=33.1) for the no pain group. This was not found to be statistically significant(P=.14).

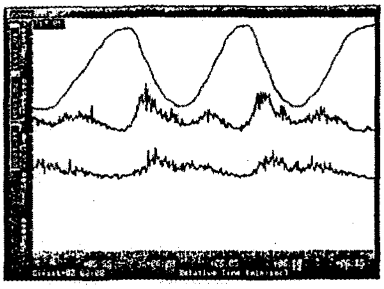

Figure 1. EMG activity of the Quadriceps showing a decline in Quadriceps activity after 90 degrees of flexion.

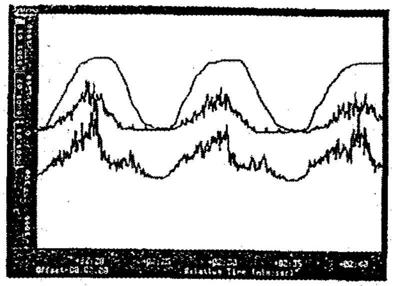

Figure 2. EMG activity of the Quadriceps during terminal knee extension showing a gradual increase in Quadriceps activity with peak activity at 180 degrees.

The mean decrease in EMG activity of the Quad muscles from the peak to the end of the range for the right LE was 34% (SD=18.9) in the pain group and 12% (SD=11.0) in the no pain group. This difference was found to be statistically significant (P=.03). The mean decrease in EMG activity of the Quadriceps for the left LE was 34% (SD=26.9) in the pain group , and 16% (SD=20.7) in the no pain group. This was not found to be statistically significant due to the large standard deviations (P=.20). Only slight decrease in Quad muscles activity was seen in both in pain group and no pain group.

Another variation seen in the EMG activity was the falling off of activity in the mid to later half of the range with a return of activity as the arm was lowered (fig. 3). This appears as a dip on the EMG graph and was defined as decline in EMG activity of more than 20% for at least 25 degrees followed by arise in activity of least 20%. The frequency of occurrence of this dip in the Quadriceps was 53% on the right side and 69% on the left side in the pain group. In the no pain group the frequency was 20% on the right and 0% on the left. (Table 3) Using a Chi square test for hompgeneity the difference was found to be statistically significant on the left

Table 2. ROM at Quad muscle peak EMG activity and percentage decrease in activity after mid range.

	Pain	No pain	P-value
Peak ROM	85 (52.3)	145 (36.5)	0.03
% decrease	34 (18.9)	12 (11.0)	0.03

Table 3. Frequency of occurrence of a dip in the Quadriceps EMG activity during terminal knee extension in subjects with and without pain.

	Pain	No pain	P-value
Dip	%(#)	%(#)	
Quad Right	53 (7)	20 (0)	0.44
Quad Left	69 (9)	0 (0)	0.03

(P=.03), but not on the right (P=.44).

The Quadriceps activity was found to

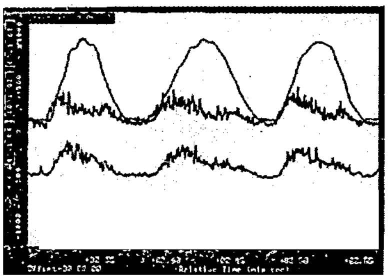

Figure 3. EMG activity of the Quadriceps during terminal knee extension showing a dip in Quad muscles activity through the end portion of the range.

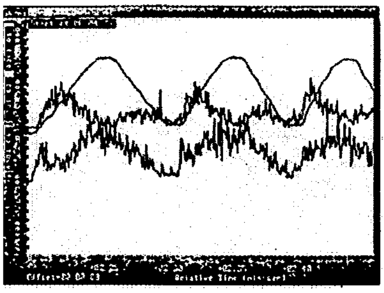

Figure 4. EMG of the Quadriceps during terminal knee extension showing an inverse activity pattern of the Quad muscles.

increase and decrease simultaneously in most subjects. However, in some individuals in the pain group an inverse pattern was seen in the EMG activity between the Quad muscles (fig. 4). The frequency of an inverse activity pattern of the Quad muscles during terminal knee extension was 0% in the no pain group but in the pain group was 31% on the right and 38% on the left. This was not statistically significant using chi square analysis due to the small sample size for the no pain group (P=.28, P=.21) respectively). Peak EMG activity of the Quadriceps did not vary significantly between the pain and no pain groups. The ratio of the peak EMG activity of the Quadriceps for the right LE was 1.16 (SD=0.49) in the pain group and 1.02 (SD=0.68) in the no pain group, and on the left was 1.36 (SD=0.86) in the pain group and 1.46 (SD=0.61) in the no pain group.

Discussion

There appeared to be no significant difference in the quantity of activity of the Quadriceps at the peak EMG activity. However, a significant difference in the characteristic of the Quad muscles EMG activity pattern during terminal knee extension was observed. The peak occurred near mid range in the pain group and near the end of the range in the no pain group.

The cause for the early activity of the Quadriceps in the pain group may be due to a guarding response, a faulty pattern adapted to protect the neck from further injury. It may also be due to weakness which would be expected in the pain group although this was not specifically measured and no significant difference was noted in fitness level and average daily lifting from questionnaire.

A greater decrease in the Quadriceps activity during the 60–90 degrees of the range, following peak EMG activity, was seen in the subjects with pain. This drop off in activity of the Quad muscles may also be a learned guarding response to protect from pain. None of the subjects reported an increase in pain during the motion, there fore if this is the case it must be a learned response. The lack of activity of the Quadriceps may indicate less effective stabilization of the knee in terminal knee extension during the last 50 to 30% of the range of motion. However, the EMG activity has not been shown to correlate directly to muscle force exerted.

The results of this study clearly show the lower trapezius to have an active role in terminal knee extension and stabilization in both group. The difficulty in recruiting female volunteers without hip or knee pain was not anticipated. The result was a small sample size in the control group which made it difficult to determine if the differences seen were in fact associated with the mechanical hip pain or normal occurrence in older adult females. Although the results cannot be applied to a broad population of adult females due to the small sample size, a difference between the pain and no pain groups was shown in the timing and recruitment pattern of the Quadriceps. In this sample early recruitment of the Quadriceps during terminal knee extension with increased activity in the first 90 degrees of motion was observed in the pain group. Because most functional activities involve less than 90 degrees of terminal knee extension motion, this finding may be even more significant during daily activities. The increased activity of the Quadriceps during the early ranges of knee motion may be a factor in the etiology of chronic pain.

Further study is recommended including the addition of EMG measurements during simulated functional activities with a larger sample size. The use of an EMG with software to assist in data analysis and summation of the EMG activity dur–

ing selected portions of the range would increase the accuracy and reliability of the measurements.

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