Effect of diacutaneous fibrolysis on the muscular properties of Gastrocnemius muscle

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Research article

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Abstract

Background: Diacutaneous fibrolysis is a noninvasive technique that has been shown to be effective in the treatment of musculoskeletal disorders such as shoulder pain, lateral epicondylalgia, patellofemoral pain syndrome and carpal tunnel syndrome. However, while diacutaneous fibrolysis is applied to soft tissue, its effects on muscular properties are unknown. The purpose of the present study was to evaluate the effects of diacutaneous fibrolysis on muscle properties as measured by tensiomyography and myotonometry in asymptomatic subjects.

Methods: A randomized controlled clinical trial with a blinded evaluator was performed. A single session of diacutaneous fibrolysis on the gastrocnemius muscle was applied to one limb (treated limb group) and the other limb was the control (control limb group). Subjects were assessed with tensiomyography and myotonometry before treatment (T0), after treatment (T1) and 30 minutes later (T2). The primary outcomes were tensiomyography and myotonometry variables. The intra-group comparison was performed with repeated measures ANOVA and Bonferroni post hoc test or Freidman test with Wilcoxon post hoc test. In the between-group comparisons, a paired t test or Wilcoxon test was used.

Results: The treated limb group showed a statistically significant increase ($p<0.014$) in tensiomyography parameters. A decrease in rigidity and increase in relaxation was also observed on myotonometry at T1, with some of the effects being maintained at T2. Rigidity and relaxation at T1 were statistically significant between groups ($p<0.05$).

Conclusions: A single session of diacutaneous fibrolysis to the gastrocnemius muscle of asymptomatic subjects produced immediate changes in muscle properties. These changes were maintained 30 minutes after the application of the technique.

Trial registration: NCT03963674.

Keywords: Diacutaneous Fibrolysis, Tensiomyography, Myotonometry.

Background

Diacutaneous fibrolysis (DF) is a noninvasive technique used to treat musculoskeletal conditions which produce pain and/or movement restriction.(1–5) DF was developed from the Cyriax deep friction massage principles and it consists of a set of metallic hooks applied to the skin to achieve a deeper and more precise application than the manual technique. The DF technique has also been demonstrated to have high subjective satisfaction.(2,3)

DF has shown to be effective in the treatment of musculoskeletal conditions such as shoulder pain,(1,2) lateral epicondylalgia,(3) patellofemoral pain syndrome(5) and carpal tunnel syndrome.(4) Previous studies have shown an improvement in pain intensity,(2–5) function, (3–5) pain-free grip strength,(3) range of motion,(2) nerve conduction(4) and patellar position.(5) The DF technique has also been shown to produce an increase of the range of motion in dorsiflexion of the ankle, (1–3) a reduction in passive resistance of dorsiflexion of the ankle(6–8), and a decrease in the myotendinous reflex of the triceps surae(7,8) when used in healthy subjects. However, the underlying mechanisms of these effects are unknown, and no studies to date have evaluated the effect of DF on muscle properties.

Because DF is applied to soft tissue, it is assumed to modify the muscle properties.(7,8) In recent years, noninvasive methods for measuring muscle properties have been developed.(9) These methods include tensiomyography (TMG), a method of assessing skeletal muscle mechanical and contractile properties in response to electrical stimuli,(10–13) and myotonometry (MMT), which measures muscle stiffness.(13,14) Both methods measure parameters that describe biomechanical muscle properties in an objective way(10,11,15,16) and have been shown to be useful in the evaluation of the musculoskeletal system both in normal and pathological states.(14,17–21)

In order to better understand the effects of DF, we aimed to evaluate the effects of diacutaneous fibrolysis on muscle properties as measured by tensiomyography and myotonometry in asymptomatic subjects.

Methods

Study design

A randomized controlled clinical trial with a blinded evaluator was conducted at the research laboratory of Universitat Internacional de Catalunya. The local ethics committee approved the study protocol (CBAS-2018-18) and the study was conducted in accordance with the declaration of Helsinki (World Medical Association, 2013). The trial was registered at clinicaltrials.gov (NCT03963674) and the study adheres to CONSORT guidelines.

Sample

Healthy subjects aged over 18 years were invited to participate in the study. Exclusion criteria for the participation were: concomitant pathologies; infiltration in the treated area 3 months previously; language limitations that made it difficult to give informed consent; and specific contraindications to DF (skin lesions, vascular abnormalities, treatment with antiplatelet agents, acute inflammatory process). Written informed consent was obtained from each subject prior to study participation.

Since there were no previous data on the variables studied, a sample of 32 subjects was collected, similar to that in the study by Veszely et al. (2000)(7) on myotendinous reflexes in the triceps surae.

Diacutaneous fibrolysis was applied to one of the lower extremities of the subjects (treated limb group). The other extremity received no intervention (control limb group). The side to be treated was randomly assigned using a random number table (Random.org).

Data collection, variables and measurements

The intervention and measurements were carried out by two therapists. The first therapist applied the DF. The second therapist, blinded to the group assignment of the lower extremity, took the measurements and recorded the data. To minimize bias, participants were not informed of any of the results obtained during measurement. The TMG and MMT of the gastrocnemius muscle were measured at the beginning of study (T0), after the intervention (T1) and 30 minutes after the intervention (T2).

Measurements were performed in a prone position on a padded bench with a foam pad placed just above the ankle which supported around five degrees of knee flexion. The thickest point of the gastrocnemius muscle was selected by palpation. Once identified, this position was marked with a permanent marker to ensure the sensor was placed in the same position on subsequent measurements.

MMT was measured using the MyotonPro (MyotonPro, Myoton Ltd., Estonia), which has a good to excellent reliability (intraclass correlation coefficient [ICC] = 0.80–0.93) in healthy and clinical populations.(23–28) The probe at the end of the device was placed perpendicular to the surface of the skin overlying the gastrocnemius muscle (Fig. 1A). Slight pressure was applied between the probe and the surface of the skin, and a short mechanical impulse (0.4 N for 15 ms), with a constant pre-compression force of 0.18 N, was delivered to the tissue directly under the probe. Three single measurements with a recording interval of 1 second were performed and mean stiffness values were used for data analysis. Stiffness (N/m) was calculated by the MyotonPRO system based on the equation: $S = \alpha_{max}$ m probe/Δl (m = the mass of the testing end, α_{max} = maximum deformation acceleration of the tissue, Δl = maximum tissue displacement).(29)

Tensiomyography was measured using a tensiomyograph (TMG-BMC d.o.o., Ljubljana, Slovenia). TMG has a good inter-observer, intra-session and between-day reliability for lower limb muscles.(16,30) TMG involves a portable device that, applied percutaneously, produces an electrical stimulus that elicits a muscular contraction, in turn detected by a digital transducer applied over the muscle belly(31) (Fig. 1B). Radial muscle displacement was measured perpendicular to the muscle belly with the digital transducer Dc–Dc Trans-Tek® (GK 40, Panoptik d.o.o., Ljubliana, Slovenia). The self-adhesive electrodes (TMG electrodes, TMG-BMC d.o.o. Ljubljana, Slovenia) were placed equidistant to the measuring point, proximal (anode) and distal (cathode) to the sensor. Electrical stimulation was applied through a TMG-100 System electrostimulator (TMG-BMC d.o.o., Ljubljana, Slovenia) with a pulse of 1 ms and initial amplitude of 50 mA. For each test, amplitude was progressively increased in 10 mA increments until there was no further increase of radial displacement or maximal stimulator output (110 mA). The parameters obtained on TMG are all based on the maximal displacement (Dm), which is the radial movement of the muscle belly after the application of the electrical stimulus, expressed in mm. The rest of the parameters obtained with TMG depend on Dm: the delay time (Td), also known as reaction or activation time, is the time between the initiation and 10% of Dm; the contraction time (Tc) is the time between 10% and 90% of Dm; the sustained time (Ts) is the time in which the muscle response remains > 50% of Dm; and the half-relaxation time (Tr) is the time in which the muscle response decreases from 90–50% of Dm.

Intervention

All subjects received 10 minutes of DF to the gastrocnemius muscle in the intervention limb (Fig. 2). The hook was applied with the pressure required to encompass the structure to be moved, and a short fast traction was applied in a transverse direction while the hook remained fixed on the skin and underlying soft tissues. No lotion was used because DF is a safe and well-tolerated technique with no adverse effects other than mild cutaneous erythema in some subjects.(1)

Participants remained lying down comfortably in a temperature-controlled room at 22ºC–23ºC to avoid altering muscle mechanical properties due to external factors.(32) Subjects were instructed to come for measurements in the following conditions(16): (1) resting, with no strenuous exercise in the previous 48 h; (2) no intake of energy drinks or supplements in the previous 48 h (no alcohol or caffeine at least 3 h before measurements) and (3) no food intake at least 2 h before measurements.

Subjects were positioned prone. DF application was begun at the myotendinous junction of the medial and lateral gastrocnemius. It was continued to the intermuscular septa between the lateral gastrocnemius and soleus, soleus and peroneus muscles, medial gastrocnemius and soleus, and flexor hallucis longus tendon and the medial aspect of the Achilles tendon. It was finished with a “scratching” technique directly to the calcaneus (at the site of Achilles tendon insertion).

Data Analysis

IBM SPSS statistics software, version 20.0 for windows was used for all statistical analyses. Descriptive statistics were calculated for all variables. Qualitative variables are expressed as counts and percentages. Quantitative variables and their differences are expressed as mean, standard deviation (SD) and 95% confidence intervals (95%CI). The initial homogeneity between the groups was analyzed using a paired t test or Wilcoxon test for quantitative variables.

The assumption of normality was assessed using the Shapiro–Wilk test. The intra-group comparison was performed with repeated measures ANOVA and Bonferroni post hoc test or Freidman test with Wilcoxon post hoc test. In the between-group comparisons, a paired t test or Wilcoxon test was used. A p value < 0.05 was considered significant.

Results

Of the 32 healthy volunteers recruited for the study, 15 were female (46.9%) and 17 were male (53.1%), with a mean age of 23.72 years (SD 5.18). The mean weight was 69.9 kg (SD 15.22), with a height of 174.2 cm (SD 10.9) and a body mass index of 22.5 (SD 3.01). The initial values of the outcome variables were homogeneous between the intervention and control limb groups (Table 1).

In the intra-group comparison, a significant increase ($p < 0.014$) in the TMG values was observed at T1 (Tc, 10.17 ms [SD 11.20]; Td, 1.46 ms [SD 1.38] and Dm, 0.48 mm [SD 0.89]). An improvement of 8.06 ms (SD 11.97) in Tc and 2.02 ms (SD 1.76) in Td occurred at T2 (Table 1).

In the neuromuscular evaluation with MMT, only the treated limbs reached a statistically significant difference ($p < 0.001$) at T1, showing a decrease in tone of 0.45 Hz (SD 0.50) and in stiffness of 9.72 N/m (SD 8.90) and an increase in relaxation of 0.55 ms (SD 1.11) ($p < 0.026$). At T2, a decrease in tone of 0.30 Hz (SD 0.62) and in stiffness of 7.72 N/m (SD 10.66) ($p < 0.028$) was observed. No statistically significant difference was found in the rest of the variables (Table 1).

In the control limbs, the only statistically significant difference ($p < 0.008$) observed was at T2 on evaluation with the TMG: an increase in Tc of 6.84 ms (SD 11.55) and in Ts of 25.02 ms (SD 31.45). In the rest of the values at T1 and T2 measured with TMG and MMT, no statistically significant difference was observed (Table 1).

In the between-group analysis, a statistically significant difference was observed at T1 in the neuromuscular values on TMG ($p < 0.017$) for the variable Tc 6.27 ms (SD 13.82). In addition, stiffness decreased 8.23 N/m (SD 7.56) and relaxation increased 0.36 ms (SD 0.90), reaching statistical significance ($p < 0.001$ and $p < 0.032$, respectively). At T2, there was no statistically significant difference between groups for any variable (Table 2).

Discussion

This is, to the best of our knowledge, the first study to examine muscular properties after DF, a treatment commonly used in clinical practice. The results of the present study show changes in multiple parameters of neuromuscular function after the application of DF to the gastrocnemius muscles. Muscular properties, or neuromuscular functions, are a group of viscoelastic and biomechanics properties(9) that prepare the muscle to perform mechanical work as part of normal neuromuscular function.(33) They therefore suggest that DF is able to modify muscle performance.

Previous studies have shown an increase in the range of motion in the dorsiflexion of the ankle, a reduction in the passive resistance of dorsiflexion of the ankle and a decrease in the myotendinous reflex of triceps surae after the application of DF.(7,8) However, the effects of the technique on viscoelastic and biomechanical properties were previously unknown.

At the beginning of the study, all variables were homogeneous for both extremities. Only the treated limb showed an improvement in TMG variables at the T1 evaluation and the T2 evaluation. On MMT, there was an increase in relaxation and a reduction in tone and in stiffness. All these differences were statistically significant and remained significant at the T2 evaluation, with the exception of Dm on TMG and relaxation on MMT. In comparison, in the control limbs the only variables that showed a statistically significant difference were Tc and Ts at the T2 evaluation (after 30 minutes of resting on the bench), probably due to muscular inactivity.

Different studies have proposed that an increase in stiffness (Dm) could be a predisposing factor to muscular injury.(34–36) According to the results of the present study, DF could be a useful technique for both the treatment and prevention of muscular injuries and pathologies. Several authors have suggested that the reduction in stiffness (increase in Dm) could lead to a loss of muscular strength, decreasing the contraction velocity (increase in Tc).(15) In the present study, strength was not assessed and could be interesting for future studies to assess if there is a reduction in strength after the application of DF as other studies have suggested. (15)

The mean reference value for the variable Dm is 8.17 mm,(11) which is double the value observed in the present study. Lower values indicate a high muscular tone and rigidity (stiffness), while higher values indicate a lack of muscular tone or high level of fatigue.(10,17,37) The initial values observed in the present study were especially low and could be due to the participants of the study being very physically active, and/or due to the tonic component of the triceps surae muscle. The increase in Dm observed after the application of DF was concurrent with the reduction in tone and stiffness observed on MMT evaluation. The results of the study show that the application of DF allowed a reduction in the tone and stiffness of the triceps surae muscle. These changes could explain the increased range of motion of dorsiflexion of the ankle observed in previous studies after the application of DF.(6–8)

The TMG variables Tr and Ts showed no statistically significant differences at T1 and T2 for both groups. Tous-Fajardo et al.(38) have suggested not using the variable Tr due to its low reliability(25) and high measurement error.(39–41)

The MMT evaluation showed a statistically significant improvement at T1 for tone, stiffness and relaxation only for the treated group; at T2 this improvement was maintained for tone and stiffness. A study by Lohr et al.(13) compared the values from TMG and MMT for paravertebral muscles. The author concluded that MMT evaluation may be more reliable than TMG evaluation, and the changes observed in tone and stiffness throughout the study were more stable than the Tc, Td and Dm values.

Given the result of this research, DF is likely to improve neuromuscular function in healthy subjects, producing changes in muscle properties. DF could be more effective when subjects have an ankle limitation or deficit, although we do not yet know whether the neuromuscular response in subjects with pathological states would occur to a similar extent as in the healthy subjects studied here. If the responses were similar, it would explain the clinical benefits found in the studies of this technique. (2–5) Future studies are required to assess this.

Limitations

The present study has some limitations. First, the long term effects of the FD technique on neuromuscular function was not evaluated. Second, the effect of a simulated FD technique was not evaluated in the present study. Although it was not the main objective of the study, it would be interesting to evaluate the effect that the superficial cutaneous stimulation of the hooks can have in comparison with the real technique, which is deeper, and it has been used in previous clinical trials analyzing the effect of FD in patients(1). However, due to the design of the study, this simulated FD technique could not be carried out.

Conclusion

A single session of diacutaneous fibrolysis produced immediate changes, which were maintained 30 minutes after treatment, in the neuromuscular response on tensiomyography and myotonometry (decrease in tone and stiffness) of the triceps surae muscle in subjects with no previous pathology.

Abbreviations

DF
Diacutaneous fibrolysis
TMG
Tensiomyography
MMT
Myotonometry
ICC
intraclass correlation coefficient
Dm
Maximal displacement
Td
Delay time
Tc
Contraction time
Tr
Half-relaxation time
SD
Standard deviation
CI
Confidence interval

Declarations

Ethics approval and consent to participate

The Ethics Committee “Comitè d’Ètica de Recerca (CER) from the Universitat Internacional de Catalunya (UIC Barcelona)” approved the study with CBAS-2018-18 reference number.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CLDC and RPRR were involved in the design and drafting of the manuscript and performed the statistical analysis of the study. APB was involved in writing and drafting the manuscript and took part in the sample recruitment process. EBG, PFM and ACA were involved in writting and drafting of the manuscirpt. CZT did the intervention. LALL collected the data and participated in the statistical analysis. All authors read and approved the final manuscript.

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Figures

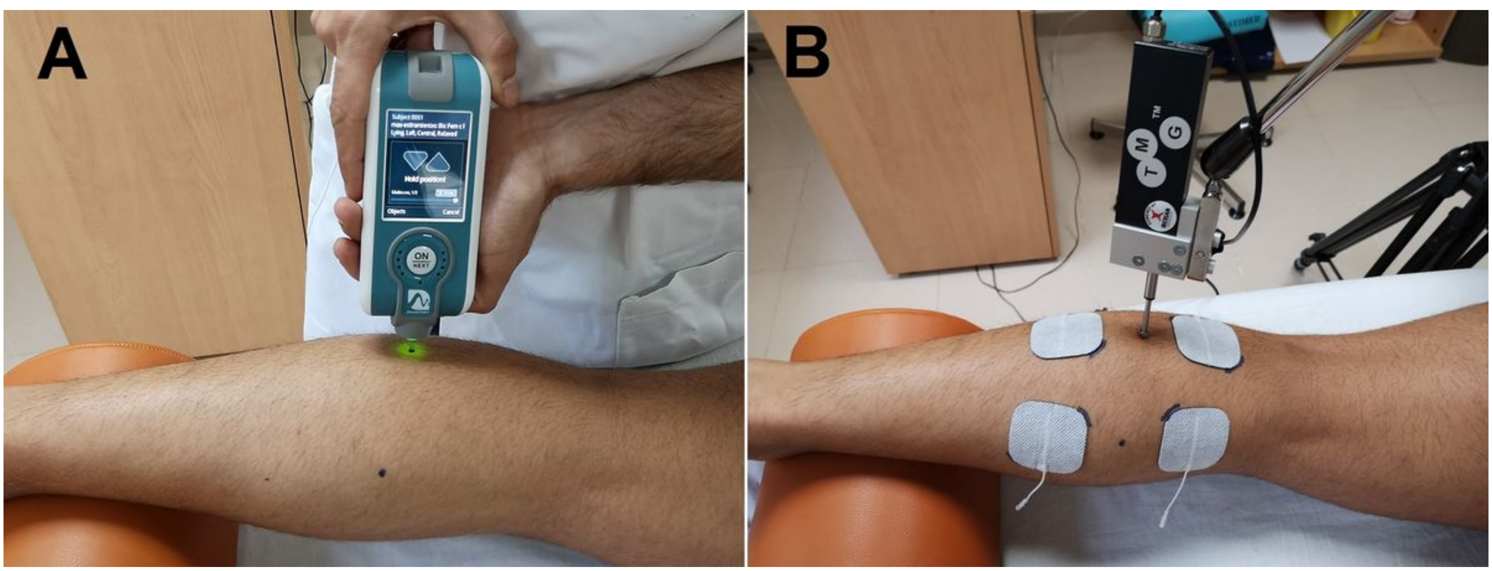

Figure 1

Measurement procedures. A: Myotonometry; B: Tensiomyography.

Figure 2

Application of Diacutaneous Fibrolysis on Gastrocnemius Muscle

Supplementary Files

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