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Case Series

Effects of percutaneous neuromodulation on the sciatic nerve in hamstring muscles. Case series

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ABSTRACT

Introduction: After an injury or surgery, one of the problems a patient faces is muscle inhibition and alterations in the activation pattern of the muscles. Innovative invasive physiotherapy techniques such as Ultrasound-Guided Percutaneous Neuromodulation (UGPN) have emerged in recent years to improve the quality and timing of treatment for this type of injury.

Case presentation: The objective of the study was to evaluate the activation of the hamstring muscles using dynamometry after the application of UGPN on the sciatic nerve in healthy subjects. The study was conducted on 8 subjects, of whom 5 were women and 3 were men. The variables measured in the study were strength and impulse, which were measured at three time points: pre-intervention, post-intervention, and 24 hours after the intervention.

Results: Significant differences in muscle strength were observed immediately after the intervention ($p=0.0078$) and at 24 hours ($p=0.0156$). Regarding impulse, significant differences were also found after the intervention ($p=0.0156$) and at 24 hours ($p=0.0391$).

Conclusions: The study shows that the 'UGPN' technique improves muscle strength and power immediately after the intervention, with the improvements maintained at 24 hours.

Keywords: muscle activation, sciatic, ultrasound-guided, strength, impulse, hamstring, percutaneous neuromodulation.

1. Introduction

Hamstring injuries are common in sports that frequently involve action such as jumping, sprinting, and high-speed movements⁽¹⁾. These injuries tend to be recurrent and can reappear with some frequency in the year following the initial injury⁽²⁾. According to a study by Ribeiro-Alvares et al.⁽²⁾, at least 30% of football players have experienced a hamstring injury, of whom 58% have had previous injuries in the same area. In addition, these injuries are associated with long recovery periods that keep the athlete out of competition for extended durations, ranging from weeks to months⁽²⁾.

Muscle activation is one of the key aspects for recovery from any neuromusculoskeletal injury⁽¹⁾. Various studies support that lack of flexibility⁽²⁾, low muscle activation⁽³⁾, and biomechanical alterations, such as abnormal jumping patterns^(2,3) or poor neuromuscular control^(2,3), significantly increase the risk of hamstring rupture. This risk is especially high after ACL surgery. Furthermore, it has been observed that muscle strength is closely related to the incidence of injuries in the lower limb⁽⁴⁾. After an injury or a surgical procedure, there is inhibition of the muscles in the affected area, thus creating differences in activation and, consequently, alterations in the movement pattern⁽⁵⁾.

There are different intervention methods to treat any dysfunction or injury involving hamstring muscles. These range from conventional and conservative physiotherapy through mobilizations, manual therapy, and neurodynamic⁽⁶⁾, electrotherapy, diathermy, or rehabilitation programs through exercises^(5,7), to more innovative techniques such as invasive physiotherapy^(8,9) or promising methods like electromagnetic⁽¹⁰⁾ fields and all the advances that improve each treatment day by day⁽⁹⁾.

Within this range of techniques is Percutaneous Ultrasound-Guided Neuromodulation (UGPN). This is an invasive technique in which, using ultrasound, the target nerve structure is identified, safety measures are established using Doppler to avoid vascular structures, and the distance to the target structure is measured. Currently, there are studies that have shown that when these currents are applied with certain parameters, they achieve greater muscle recruitment⁽⁹⁾. However, no studies have been found that analyze the effect of UGPN specifically on the sciatic nerve with the aim of increasing muscle activity, so the present case study aims to investigate whether an increase in muscle activity occurs immediately after the application of UGPN and whether this increase is maintained at 24 hours.

2. Description of the case series

2.1 Patient information

The study's inclusion criteria were: (a) being over 18 years old, (b) not having or having had hamstring pathology such as tears, tendinopathy, or muscle overload in the past three months, and (c) not having or having had joint injuries or surgery in the knee or hip. On the other hand, the exclusion criteria were: (a) venous, cardiac, pulmonary, etc., pathologies, (b) claustrophobia, (c) wound or alteration in the needle insertion area, (d) use of psychotropic drugs, (e) chronic use of analgesics, (f) use of anticoagulants, (g) sensory disorders, (h) neurological disease.

2.2 Clinical findings

Given the characteristics of the study and the inclusion and exclusion criteria, no diagnostic tests were required, nor were there any relevant clinical findings, as the subjects were healthy.

2.3 Therapeutic intervention

The patients were placed in the prone position with a cushion under their ankles. The physiotherapist carried out various hygiene measures such as hand washing, wearing gloves and probe covers, and proper asepsis on the patient's skin. After ensuring that the relevant safety measures were maintained, with the help of an ultrasound device, the sciatic nerve was located on the middle third of the thigh between the greater trochanter and the knee joint. Next, two short-axis needles were inserted at an 80° angle, one from medial to lateral through the semitendinosus and the other from lateral to medial through the biceps femoris. Considering the anatomical variability of both the sciatic nerve's arrangement and its axons, before starting the technique, the correct placement of the needles was verified using a pointer. Thus, if stimulating each needle generated a contraction of the muscles innervated by the corresponding axons, the placement was considered valid. Otherwise, the placement of the electrodes was adjusted until both territories, the tibial and peroneal parts, were stimulated. Next, the clips coming from the same channel of the electrostimulator (ITO ES-160 Ryodoraku) were connected to each of the needles. Before starting the neuromodulation, the parameters of 10 Hz frequency and a pulse width of 250 µs were set, and the intensity was gradually increased until a non-painful contraction was achieved. At that moment, neuromodulation was initiated by delivering 10 stimuli of 10 seconds each at an intensity tolerable for the subject according to the protocol described by Valera et al.⁽¹¹⁾ and previously used in other studies⁽¹²⁾. Between each stimulus, a rest period of 10 seconds was allowed. After completing the test, both the clamps and the needles were removed, and with the help of gauze, ischemic pressure was applied for 30 seconds to the puncture site to prevent possible adverse effects.

2.4 Study Variables

Muscular strength, measured in newtons, was considered the primary variable, and impulse in newtons x sec as the secondary variable. Both variables were measured following the protocol described by Oxford SW et al.⁽¹³⁾. Both variables were obtained using the DynaMo Vald Performance dynamometer, which has been shown to be reliable for assessing muscular strength in patients with neck pain, with an intraclass correlation coefficient (ICC) greater than 0.76 and a coefficient of variation less than 13.8%⁽¹³⁾.

A measurement was taken before the intervention, another immediately after it, and a third measurement 24 hours after the intervention. The measurement was performed in the prone position, placing a dynamometer on the posterior aspect of the calcaneus. Participants were asked to perform a knee flexion while maintaining maximum force at 90° of flexion, following a protocol of 3 sets with 3 repetitions of 5 seconds, resting 10 seconds between each repetition and 30 seconds between sets. The first set was used to familiarize themselves with the test, so the patient was asked to exert 30-50% of their maximum strength. In the second set, 80% of their maximum strength was requested. Finally, in the last set, they were asked to exert their

maximum strength. From these last three repetitions, the best result obtained in the parameters of force (N) and impulse (N*s) was selected⁽¹³⁾. The same measurement protocol was carried out again immediately after the intervention and 24 hours later.

2.5 Statistical analysis

The data analysis was carried out using the SPSS Statistics software. The significance level was set at $p < 0.05$ and the confidence interval limits at 95%. To determine whether the variables followed a normal distribution, the Shapiro-Wilk normality test was used. Once the normal distribution of the variables was established ($p > 0.05$), an initial descriptive analysis was performed, showing means and standard deviations, and a repeated measures ANOVA was conducted to compare the differences between the measurements before and after the intervention.

3. Results

Eight subjects were selected, of which 5 were women and 3 were men, with a mean age of 32 ± 13.52 years. The mean height was $167.75 \text{ cm} \pm 9.23$, and the mean weight was $65.38 \text{ kg} \pm 14.09$. Of the 8 subjects, 4 exercised regularly with an average of 5 hours of exercise per week, including running, cycling, and strength training. The other 4 exercised sporadically, averaging 2 hours per week. All of them exercised at an amateur level.

No adverse effects were observed following the procedures. Regarding strength and impulse, the results were as follows:

Strength

Significant differences in muscle strength were observed immediately after the intervention ($p < 0.05$) and at 24 hours ($p < 0.05$). The mean strength values were $185.13 \text{ N} \pm 51.40 \text{ N}$ before the intervention, $212.50 \text{ N} \pm 55.92 \text{ N}$ immediately after the intervention, and $216.88 \text{ N} \pm 53.64 \text{ N}$ at 24 hours after the intervention (Table 1).

Impulse

Regarding impulse, significant differences were also produced between pre-intervention and post-intervention ($p < 0.05$), with a change in impulse from $387.38 \text{ N*s} \pm 85.27 \text{ N*s}$ to $467.25 \text{ N*s} \pm 133.86 \text{ N*s}$. Likewise, changes were observed between pre-impulse and 24-hour follow-up ($p < 0.05$), the latter being $497.25 \text{ N*s} \pm 153.02 \text{ N*s}$ (Table 1).

Table 1. Descriptive statistics.

	Mean / Standard Deviation				
	Mean (SD) Pre	Mean (SD) Post	Mean (SD) Post 24h	Difference Pre-post. Mean (SD); p-value	Difference Pre-24h. Mean (SD); p-value
Strength (N)	185,13 (52,40)	212,50 (55,92)	216,88 (53,64)	27,38 (3,52); $p=0,0078$	31,75 (1,24); $p=0,0156$
Impulse (N*s)	387,38 (85,27)	467,25 (133,86)	497,25 (153,02)	79,88 (48,59); $p=0,0156$	109,88 (67,75); $p=0,0391$

4. Discussion

This study continues the research conducted by various authors in which changes in muscle activity were found following the intervention with UGPN^(9,12,14). In this case, significant differences were observed between the strength measurements taken immediately after the intervention and 24 hours later, indicating that not only were their improvements in strength following the application of UGPN, but these improvements were maintained for at least 24 hours. These results are consistent with those obtained by Ormazabal et al.⁽¹²⁾ in their study conducted on subjects with multiple sclerosis using the same UGPN parameters that were used in the present study. Another study on CrossFit athletes did not find significant changes between groups in strength, although the groups that received UGPN showed improvements over time⁽⁹⁾. The reason could be that the CrossFit practitioners already had a high level of strength, and therefore the potential for improvement is lower than in our study, as the authors themselves refer to this “ceiling effect”.

As a novelty in this study, the impulse (N*s) was analyzed when measuring the effects of the UGPN technique on the sciatic nerve. In the case of impulse, as with force, statistically significant results were also obtained.

Taking these results into account, and although a cause-effect relationship cannot be established due to the type of study conducted, the UGPN technique applied to the sciatic nerve for the activation of the hamstring muscles appears to be effective in terms of improving strength and propulsion. The main limitation of the study is the type of study and the small sample size, as well as its heterogeneity.

5. Conclusion

The application of UGPN on the sciatic nerve could show a positive effect in improving strength in healthy subjects, with the improvement being maintained during the 24 hours following the application of the technique. However, given the limitations of the study described above, it is not possible to draw definitive conclusions. Therefore, this case study could be the pathway for future research to obtain significant results in this area.

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Informed Consent of the Patient

Each patient was explained every procedure that was going to be performed on them and was given the corresponding informed consent. They were granted a few minutes to read and sign this informed consent, which detailed with precision all the benefits and possible risks associated with these techniques, emphasizing the frequency of such risks.

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Conflicts of Interest

The authors declare no conflicts of interest.

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