Acute effect of neuromuscular electrostimulation in the torque and cross-sectional area of the Extensor Digitorum Communis muscle. Real-time ultrasound imaging

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ABSTRACT

Neuromuscular electrostimulation (NMES) is a therapeutic resource widely used by most physiotherapists with the objective of favoring muscle strengthening, prevention or recovery from atrophy due to disuse, however there is still no scientific consensus on which is the most effective current for this purpose. This study aims to evaluate the acute effect induced by low and medium frequency electrostimulation in an isometric contraction of wrist extension and compare them with the maximum voluntary isometric contraction (MVIC) (1) in the force production capacity and (2) in the vertical and horizontal values of the cross-sectional area of the Extensor Digitorum Communis muscle (EDC). There are no differences between the mean values for height or width between the TENS and Kotz currents, nor between the two NMES currents and the MVIC. No differences were found in the capacity for power generation of the administration of NMES currents and the MVIC. No differences were found in the height or width values between the TENS and Kotz currents, nor between the two NMES currents and the MVIC. No differences were found in the capacity for power generation of the exclusive administration of NMES currents and the MVIC, in a population of healthy adults.

Keywords: Neuromuscular electrostimulation; Torque; Cross-section muscle; Ultrasounds.

INTRODUCTION

Neuromuscular electrostimulation (NMES) is a therapeutic resource widely used by most physiotherapists with the objective of favoring muscle strengthening, prevention or recovery from atrophy due to disuse and increasing muscle endurance [1]. In clinical practice, several types of currents can be used, Transcutaneous Electrical Nerve Stimulation (TENS) and Kotz (also known as Russian Current) are among the most common, the first is a low frequency pulsed current (40-80Hz) and the second is a medium frequency current (2500 Hz) [1-2]. NMES cause anatomical changes in thickness, length, width, cross-sectional area, fiber angle and fascicle length, and the ultrasound image, allowing a better understanding of muscle function [1, 3]. The use of this resource has been explored for several years, however there is still no scientific consensus on which is the most effective current. This study aims to evaluate the acute effect induced by low and medium frequency electrostimulation in an isometric contraction of wrist extension and compare them with the maximum voluntary isometric contraction (MVIC) (1) in the force production capacity and (2) in the vertical and horizontal values of the cross-sectional area of the Extensor Digitorum Communis muscle (EDC).

MATERIALS AND METHODS

Study design: This study presents a quantitative, analytical and transversal study with a repeated measures design**. Sample:** The present study included 38 healthy female participants, aged between 18 and 35 years, with a similar body mass index, who did not use hormonal, oral or injectable contraceptives, or other contraceptives. The sample exclusion criteria included: pregnancy history; lower limb and nervous system injuries and use of any type of medication. The International Physical Activity Questionnaire (IPAQ) was used in order to assess and ensure the same level of physical activity and sedentary behaviour of the participants [4]. **Instruments:** The Sono Plus 612 device, with adhesive electrodes of 3 cm in diameter (EnrafNonius® - Netherlands), for the application of two NMES (TENS and Kotz). The Globus ergometer V.4.42 dynamometer (Globus – Italy), for measuring the value of the torque. The ViamoTM ultrasound (Toshiba Medical Systems Corporation - Japan) with PLT-704ST transducer for the real-time ultrasound

images. **Procedures:** The experimental part of the study was developed at the Rehabilitation Research Centre of ESS do Porto. All were subjected to the application of two NMES (TENS and Kotz). The forearm was divided into three zones and the electrodes were placed in the two most proximal zones, on top of the muscle. The first current had as parameters: frequency 50Hz and pulse duration 400μA, the second current had: frequency 2.5 kHz with modeling at 50 Hz, also includes the performance of maximum voluntary contraction and the resting state of the EDC. For the two NMES, the following parameters were selected: rise time of 1 second, plateau of 6 seconds, descent time of 1 second and rest time of 60 seconds [1-2]. During the application of electric current, the maximum torque value for each individual was simultaneously measured. The torque (N.m) was calculated by multiplying the value obtained by the dynamometer cell (N) with the distance (m) from the articular axis to the point where the cell was applied [5]. The participants were instructed to perform maximum isometric contraction when they felt the intense, but bearable electric current. Three contractions were performed for each procedure, except the resting state, with 2 minutes of rest between each [4-6]. The Acute effect in the cross section (height and width), was observed through real-time ultrasound images that were placed transversely on EDC muscle. This instrument is valid for measuring muscle size [7], measuring the cross section, vertical and horizontal lines were marked at the ends of the muscle to measure the distance between these lines to calculate the values of muscle height and width. **Ethics:** The study was approved by the ethics committee of the Escola Superior de Saúde do Porto (001350). All participants included in the study signed an informed consent form. **Statistics:** The SPSS 24.0 software (Statistical Package for the Social Sciences®, IBM Portugal, Lisbon, Portugal) was used, considering a significance level of 0.05. In the statistical analysis, the normality of the distribution of the variables was confirmed using the Shapiro-Wilk test, therefore, the t test was used for paired samples.

RESULTS AND DISCUSSION

The final sample, consisting of 38 participants, mean values and respective standard deviations: 21.7 (4.6) years, 51.7 (0.9) kilograms, 165.7 (14.8) meters. The results showed that the torque produced exclusively due to NMES, independently of the electrical stimulation that was used, is similar to that produced by MVIC. Therefore, it was demonstrated that the capacity for power generation of the exclusive administration of the NMES was no different from that achieved with the MVCI. There were no statistically significant differences between the mean values for height or width between the TENS and Kotz currents, nor between the two NMES currents and the MVIC ($p > 0.05$). These results refute some of the findings in the literature in relation to use of NMES, namely that the muscle contraction induced by the NMES can reach up to 80% of the MVIC [8], in the present study it was approximately similar. There were no statistically significant differences regarding the height and width of the muscle belly between muscle contraction induced by electric current and a MVIC, as well as between currents. During the use of the TENS the average torque values reached by the participants was 7.088Nm (99.10% of the maximum voluntary contraction) and during the use of Kotz it was 7.3Nm (102.06% of the MVIC), and there was also no differences between them. Future studies should be conducted in this direction to better assess the relevance of using this strategy in clinical practice.

CONCLUSION

No differences were found in the height or width and in the capacity for power generation values between the TENS and Kotz currents, nor between the two NMES currents and the MVIC in a population of healthy adults.

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