Upper trapezius relaxation induced by TENS and interferential current in computer users with chronic nonspecific neck discomfort: An electromyographic analysis

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Abstract.
BACKGROUND: Recent studies have shown that a transcutaneous electrical nerve stimulation (TENS) and interferential current (IFC) application reduces pain in subjects with musculoskeletal disorders. However there are no clinical trials evaluating or comparing the muscle relaxation generated for these devices.

PURPOSE: To compare the muscle relaxation of the upper trapezius induced by the application of TENS and IFC in females with chronic nonspecific neck discomfort.

METHODS: Sixty-four females between 18 and 40 years of age and a history of nonspecific neck discomfort were randomly assigned to a TENS or an IFC group. The women in the TENS (N = 32; mean age 22 years) and IFC (N = 32, mean age 23 years) group were submitted to current application during 3 consecutive days and were assessed by electromyography (EMG) in different times aiming to quantify the muscular tension of the upper trapezius. A visual analogue scale (VAS) was used as pain measure at baseline (before TENS or IFC application) and at the end of the study.

RESULTS: At baseline, demographic, pain, and EMG assessment data were similar between groups. Those in the IFC group had a significant trapezius relaxation after 3 IFC applications when compared to baseline and intermediate evaluations (P < 0.05). In contrast, the same analysis showed no significant difference between all assessments in the TENS group (P > 0.05). In relation to pain relief, both groups showed an improvement at the end of the study when compared to baseline (both, P < 0.05). The between-group analysis showed no difference for the subjects who received such IFC as TENS application (P < 0.05).

CONCLUSION: IFC induced the upper trapezius relaxation after 3 sessions in females with neck discomfort, but the TENS application did not change the muscular tension. However, these results should be carefully interpreted due to the lack of differences between groups. A significant pain decrease was found in the subjects of both groups, however, only the IFC application presented a clinically important improvement.

Keywords: Electrical stimulation, transcutaneous electrical nerve stimulation, muscle relaxation, electromyography, neck pain

1. Introduction

The stress level of the population has increased, leading to a compensatory muscle tension, and therefore, several musculoskeletal disorders [1]. These disorders may affect specially the postural muscles, because they are the most requested during functional ac...
tivities [2,3]. The muscles of the neck and shoulder are the most affected in workers of different occupations, especially those that involve repetitive movements as typing in a computer for a long time [4,5]. This pattern of muscle tension is found mainly in the upper fibers of the trapezius muscle, and for this reason, it is an area much investigated in the literature by electromyography [1,4,6].

Thus, the vicious cycle involving stress, repetitive activities, and tension in the trapezius also leads to greater difficulty in returning to basal muscle activity after a workday [5]. It is usual in the clinical practice finding subjects with muscular discomfort in the neck area, even without a clear diagnosis of disc herniation, radiculopathies, spine injuries or degenerative processes.

There are several modalities used in physical therapy focusing on pain relief and muscle relaxation such as physical agents for cooling, heating, electrical stimulation, and others [7]. The transcutaneous electrical nerve stimulation (TENS) and the interferential current (IFC) are noninvasive methods used for analgesia, but there is a lack of consensus in the literature regarding the muscle relaxation effects [8]. TENS has been described as a device that generates alternating electrical current of low-frequency, acting at the sensory level by closing the spinal cord gates, releasing endorphins, and helping in tissue repair [9]. On the other hand, the IFC is the application of alternating medium-frequency (4.000 Hz) amplitude modulated at low frequency, presenting a higher tissue penetration and less discomfort when compared to TENS [8,10].

The analgesic effects of these currents are already well established in the literature, however, there are no studies comparing the muscle relaxation by low- and medium-frequency currents on a sensory level, i.e., using current intensity (mA) only in the sensory threshold. Therefore, the aim of the present study was to compare the muscle relaxation of the upper trapezius (primary outcome) and pain relief (secondary outcome) induced by the application of TENS and IFC in females with chronic nonspecific neck discomfort.

2. Methods

2.1. Participants

Sixty-four women with chronic nonspecific neck discomfort participated in the study and were randomly assigned to one of two groups: a TENS group ($n = 32$) and an IFC group ($n = 32$). All volunteers were informed about the procedures for the study and signed informed consent written in accordance with the National Health Council, resolution 196/96. This study was approved by the Research Ethics Committee of Centro Universitário São Camilo (CUSC), Brazil.

Females between 18 and 40 years old were included if they had a history of chronic nonspecific neck discomfort with a visual analog scale (VAS) score over 3/10, if they used computer for at least 14 hours per week or 2 hours daily, and if they had pain during trigger point palpation of the neck area. For this evaluation, the trigger point was considered active if the subject presented local pain during a moderate digital pressure in the middle third of the upper trapezius. The participants were recruited from the college students of the university by a single physical therapist with more than 10 years of clinical experience in spine rehabilitation.

Females were excluded if they had musculoskeletal disorders, physical therapy in the last 6 months, referred or irradiated pain, body mass index over 28, previous surgery involving the upper extremities, if were pregnant or using corticosteroids or anti-inflammatory medication, as well as other traditional TENS or IFC contra-indications [1,7]. A standard cervical clinical examination was performed to rule out concomitant pathology of the upper extremities.

The assignment of subjects in the two groups was performed randomly using opaque and sealed envelopes containing the names of the groups: TENS and IFC. The envelopes were picked by an individual not involved in this study. Three therapists were trained in delivering the device protocols used for the study and provide all treatment.

2.2. Intervention

The TENS and IFC applications and electromyographic (EMG) registration were performed on each subject in a standardized protocol with duration of 5 days. On the first day, subjects remained at rest in the supine position for 30 minutes before the first assessment. We then analyzed the RMS value of the EMG signal of both sides of the upper trapezius muscle. This first registration (initial evaluation) was performed with the subject seated on a standardized chair with the forearms supported.

After the initial evaluation, the subjects of both groups (TENS and IFC) were submitted to the current application by self-adhesive silicone electrodes, with
the bipolar technique, i.e., 2 electrodes on each side of the upper trapezius for 30 minutes. In each side, one electrode was placed laterally on the C7 spinous process, and the other on the supraspinatus fossa. The intensity (mA) was raised according to the subject’s tolerance, remaining in the sensorial level. Soon after this application, another EMG registration was performed at the same condition mentioned before (evaluation 1).

On the second day, the patients received only the TENS or IFC application on the upper trapezius muscle bilaterally for 30 minutes. On the third day, the patients were initially assessed in relation to the EMG registration (evaluation 2), followed by TENS or IFC application. After this application, we performed the EMG registration again (evaluation 3). There were no activities or analysis on the fourth day.

On the fifth day, only the EMG registration (final evaluation) was performed (Fig. 1). The same procedure prior to the analysis was performed in the evaluation 2 and final evaluation, i.e., the subjects remained at rest in the supine position for 30 minutes to avoid or minimize possible tensions due to the test situation (“lab effect”). Although it was not the main purpose of the study, we performed a pain assessment by visual analogue scale (VAS) at initial and final evaluation. The 0–10 cm VAS, where 0 represented “no pain” and 10 represented “worst imaginable pain”, was used to assess cervical pain intensities. The VAS has reported a minimal clinically important difference (MCID) of 2.0 cm (± 0.3 cm at a 95% confidence interval) [11].

2.3. Instrumentation and EMG

The TENS (Quark®, TensVif 993) equipment was used in the Burst mode, with a frequency of 100 Hz and pulse duration of 150 μs. The IFC (KLD Biosistemas, Endophysys) equipment had a carrier frequency of 4,000 Hz, an amplitude modulated frequency (AMF) of 100 Hz, a variation frequency (ΔF) of 60 Hz, and a slope of 6/6. The intensity (mA) in both devices was set at the tactile sensation threshold.

The EMG equipment utilized in this study was the portable CS400/EMG System with eight channels. The EMG rectified signals of the trapezius muscle were obtained by surface Ag/AgCl (10 × 20 mm) differential-type electrodes with inter-electrode capture distance of 20 mm and a pre-amplification of 20-fold, and send to the amplifier (frequency range: 20–500 Hz; noise signal rate: 3 μV RMS; CMMR: 100 dB), which has a gain of a factor of 50, achieving a gain of 1,000 fold for the EMG signal.

The capture electrodes were positioned at the midpoint between the spinous process of the C7 vertebra and the acromion bilaterally according to SENIAM – European Recommendations for Surface Electromyography criteria [12]. The reference electrode was positioned in right lateral malleolus. Before the electrodes were positioned, we shaved the exposed area, followed by sterilization with hydrated 70% ethyl alcohol. Afterwards, an EMG signal capture was performed in the predetermined condition for 30 seconds. The first and last 5 seconds were removed. Thus, the raw EMG signal was rectified and the RMS values were calculated during the intermediate 20 seconds.

2.4. Statistical analysis

Data were analyzed with SPSS Version 13.0. (SPSS, Chicago, IL, USA). Descriptive statistics for demographic data and all outcome measures were expressed as averages and standard deviations. Comparison between the dominant and non-dominant side was performed using dependent T test. The data for the RMS
value of the EMG signal were analyzed using separate 2 × 5 (group by time) mixed model ANOVAs. The factor group had 2 levels (TENS and IFC) and the repeated factor time had 5 levels (initial, 1, 2, 3, and final evaluations).

3. Results

3.1. Baseline data

There was no statistically significant difference \((P > 0.05)\) for age, height, body mass, and duration of symptoms between the participants in the TENS and IFC groups (Table 1). There was no statistical difference between the dominant and non-dominant side in the intra-group analysis (TENS, \(P = 0.5\) and IFC, \(P = 0.6\)). For this reason, both sides were considered together for the comparison between groups. There was also no statistically significant difference \((P = 0.4)\) between groups for the studied variables (EMG data and VAS) at baseline (initial evaluation) (Table 2).

3.2. EMG registration and pain

There was a statistically significant group-by-time interaction for the 2-by-5 mixed model ANOVA for muscle tension and pain assessment measures \((P < 0.01)\). Planned pairwise comparisons for the RMS value of the EMG signal indicated that the subjects in the IFC group had significant muscle relaxation at final evaluation when compared to baseline (initial evaluation), evaluations 1, 2, and 3 \((P < 0.01, P < 0.02, \text{ and } P < 0.05, \text{ respectively})\). The same analysis showed no significant difference between all assessments in the subjects of the TENS group \((P > 0.05)\). In relation to pain relief, both groups showed an improvement at final evaluation when compared to baseline (both, \(P < 0.05\)).

The analysis of differences between groups at evaluations 1, 2, and 3, as well as final evaluation showed no difference for the subjects who received such IFC as TENS application \((P < 0.05)\). There was also no difference in the between-group analysis for VAS \((P > 0.05)\).

It is important to highlight that we controlled the use of any anti-inflammatory, muscular relaxant, or analgesic medication, and no subject reported performing physical activity during this period.

4. Discussion

This randomized interventional study aimed to compare the muscular relaxing effects of the upper trapezius induced by TENS and IFC application in females who used a computer daily and presented chronic un-specific neck discomfort. The results of EMG evaluation showed that IFC can reduce the trapezius muscle tension; however, three sessions are needed to achieve this effect. On the other hand, there was no relaxation effect using the TENS application. Both groups presented a decrease of the pain level. It is important to highlight that there was no difference between groups for all assessments.

The assessment of muscle activity can be performed by EMG [13], since the RMS value is a tool of quantifying and processing the EMG signal, showing a linear relationship with muscle tension at rest and during functional tasks [14].

Previous studies have linked the TENS and IFC application as a tool to provide pain relief and muscle relaxation [8,15,16]. There is also hypothesis about effects of increasing blood flow and excitation of large diameter afferent fibers (Gate theory) [9,17,18]. However, there is a lack of clinical studies using quantitative assessment for muscle relaxation induced by TENS and IFC.

The results of the present study demonstrate that a decrease in muscular activity can be observed at sensorial level stimulation in medium-frequency current, i.e., using current intensity (mA) only in the sensory threshold. However, this relaxation appears to be more related to cumulative rather than immediate effect, because we observed that there was significant relaxation in the final evaluation when compared to initial assessment for the subjects who received IFC application. This information corroborates the data from recent meta-analysis conducted by Fuentes et al. [15]. A hypothesis for the lack of effect using TENS applica-
Table 2

<table>
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<th>Outcome measures for the TENS (n = 32) and IFC (n = 32) groups</th>
<th>VAS (0–10 cm)</th>
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<tr>
<td></td>
<td>Initial Evaluation 1 Evaluation 2 Evaluation 3 Final</td>
<td>Initial Final</td>
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<tr>
<td>TENS*</td>
<td>10.5 ± 1.7 (9.9, 11.1) 11.4 ± 3.8 (10.0, 12.8) 10.8 ± 1.9 (10.1, 11.5) 10.5 ± 1.9 (9.8, 11.2) 10.3 ± 1.8 (9.6, 10.9)</td>
<td>4.2 ± 1.3 (3.7, 4.7) 2.9 ± 0.5 (2.7, 3.1)</td>
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<tr>
<td>IFC*</td>
<td>11.2 ± 2.5 (10.3, 12.1) 10.5 ± 1.4 (10.0, 11.0) 10.5 ± 1.7 (9.7, 10.4) 10.2 ± 1.1 (9.8, 10.6) 9.7 ± 0.8 (9.4, 10.0)</td>
<td>4.6 ± 1.9 (3.9, 5.3) 2.4 ± 0.5 (2.2, 2.6)</td>
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Abbreviations: TENS, Transcutaneous Electrical Neural Stimulation; IFC, Interferential Current; RMS, Root Mean Square; EMG, Electromyographic; VAS, Visual Analogue Scale. *Values are mean ± SD (95% confidence interval).

The present study contributed to the literature because this is the first clinical study investigating immediate and cumulative muscle relaxation by surface EMG in subjects with chronic discomfort in the cervical area. Further research is needed to relate other IFC and TENS parameters such as modulated or carrier frequency, duty cycle, intensity, and time. In addition, these findings need to be correlated with clinical evaluations of local microcirculation in subjects with chronic diseases, neck, and superior limb disorders, as well as in spastic muscles of neurological patients.

5. Conclusion

IFC induced the upper trapezius relaxation after 3 sessions in females with chronic unspecific neck discomfort, but the TENS application did not change the muscular tension. However, these results should be carefully interpreted due to the lack of differences between groups. A significant pain decrease was found in the subjects of both groups, however, only the IFC application presented a clinically important improvement.

Ethics

The protocol for this study was approved by the Ethics Committee on Research of the Centro Universitário São Camilo (CUSC).

References


