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Research Article

Transcutaneous Electrical Nerve Stimulation As Prophylaxis Against Delayed Onset Muscle Soreness Of Quadriceps And Gastrocnemius Muscles.

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Abstract

Transcutaneous Electrical Nerve Stimulator (TENS) has been known to alleviate muscle soreness, tightness, and spasms with concurrent pain. Physiologically, it enhances muscle blood flow during exercise and provides temporary analgesia. Delayed onset muscle soreness (DOMS), which generally occurs 24 to 72 hours after a vigorous unaccustomed activity may limit optimum physical function. There is a limited resource to prevent its occurrence. In the present study, TENS was applied before and after an endurance exercise to determine its effectiveness as prophylaxis against DOMS in quadriceps and gastrocnemius muscles. Sixty participants were assigned randomly into 4 groups (negative control, positive control, experimental 1, and experimental 2) and performed 3 sets of preselected endurance exercises with 2-minute rest interval. The experimental groups received TENS (MH6200, Taiwan) for 20 minutes with predetermined parameters. Data gathering immediately started in subsequent hours after the exercises and reported as onset of pain, duration of pain, and pain intensity recorded using the Numerical Pain Rating Scale (NPRS). Results show that the application of TENS did not prevent the onset of DOMS. However, it lessened the perceived pain intensity (p value – 0.0000), delayed the onset of pain (p value – 0.0016) with significantly reduced pain duration (p value – 0.0000). Interestingly, 43% of the participants in the experimental groups reported that pain was perceived in only one of the two muscles, mainly in the calf area. This study is largely influenced by the COVID-19 crisis. A similar study with slight modification utilizing a more obstinate process may yield better results.

Keywords : *Transcutaneous Electrical Nerve Stimulator; Delayed Onset Muscle Soreness, Analgesia, Prevention, Endurance Exercise.*

INTRODUCTION

Delayed onset muscle soreness (DOMS) is a common problem that can interfere with the performance of activities for the untrained individual, as well as interfere in a rehabilitation program. Individuals who engage in sporadic, strenuous physical activity or abruptly increase intensity of training often experience muscle soreness for 48 hours or more post-activity (Weber, 1994). The intensity of discomfort increases within the first 24 hours following cessation of exercise, pain and tenderness peaking between 24 and 72 hours, and eventually disappears by 5–7 days post-exercise (Cheung et al., 2003).

Several hypotheses proposed and explained the mechanism of DOMS. Lactic acid theory assumes that lactic acid continues to be produced following exercise cessation (Armstrong, 1984). Muscle spasm theory introduces that vigorous eccentric exercises performed after periods of inactivity increases compression of local blood vessels, ischemia and accumulation of pain chemicals (Bobbert et. al, 1986). Moreover, connective tissue damage theory presents that Type II or fast twitch fibers are more susceptible to stretch-induced injury and muscle soreness due to a less tough connective tissue sheath (Stauber, 1989). Other theories such as muscle damage theory (Friden et. al, 1983), inflammation theory (Smith, 1991), and enzyme efflux theory (Gulick et. al, 1996) suggest the role of contractile component (sarcomere) of the muscle, inflammatory cell infiltration, and calcium accumulation in injured muscles as factors to DOMS developmentVarious treatment strategies aimed to alleviate the symptoms of DOMS, restoring the maximal function of the muscles, and reducing the magnitude of initial injury have

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been reported. Interventions include cryotherapy, stretching, anti-inflammatory drugs, ultrasound, electrical current techniques, homeopathy, massage, compression, hyperbaric oxygen, and exercise.

Transcutaneous electrical nerve stimulation (TENS) is a technique that uses electrical current to alleviate muscle soreness, tightness and even spasms with pain. It also improves the muscle blood flow and is a good analgesic for muscle pains. The application of TENS during aerobic and isometric exercises reduced pain intensity and improved performance which showed improvement of muscle blood flow redistribution (Astokorki and Mauger, 2017). The application of TENS after 24 hours DOMS reduced pain summation during exercise and also increased physical tolerance (Manovsky-Arnold et al., 2013).

During the application of TENS, inhibition and reduced pain are improved due to the peak action of electrostimulation that could also have a preventive action against muscle soreness (DeSantana et al., 2008). No study has investigated the use of TENS with this aim. Hence, this study will focus on the preventive effects of TENS in an endurance exercise-induced DOMS. The researcher assumes that TENS may have a preventative effect on DOMS production. Results of the study can be used as a basis in clinical setting to lessen the occurrence of DOMS after performance of exercises.

MATERIALS AND METHODS

Research Design

An experiment is conducted to determine the differences in onset, intensity, and duration of muscle soreness between groups applied with TENS and pharmacological agent (Mefenamic acid) prior to exercises versus the group without any intervention.

Sampling Design and Technique

Sixty (60) participants were randomly selected from the 70 prospects with age ranging from 20 to 30 years old. All participants lived a sedentary lifestyle. Four (4) groups with 15 participants from each group received different interventions namely: Group 1 (negative control) received no interventions, Group 2 (positive control) received NSAID before exercise, Group 3 (Experimental 1) applied with low intensity TENS before and after exercise with a frequency of 50-100 Hz, and a pulse width of 50-200 µs, and Group 4 (Experimental 2) applied with high intensity TENS before and after exercise with a frequency of 2-4 Hz, and a pulse width of 100-400 µs.

Instruments

All participants from each group engaged in lower extremity endurance exercises for 30 minutes. Exercises were performed sequentially using the following parameters: 20 repetitions, 3 sets, with 5 seconds rest between exercises, and 2-minute rest interval between sets.

Table 1. Endurance Exercise Program.

Exercise	Repetition
High knees	20
Butt kicks	20
Jumping lunges	20
Toe top hops	20
Jumping jacks	20
Single-leg Calf Raise	20
Jump squats	20

Note: Program considered as 1 set; With 2 minutes rest in between sets.

Experimental groups were applied with TENS for 20 minutes before and after an endurance exercise. Equipment used is MH6200, Taiwan TENS manufactured by Medihightech Medical Company.

Procedures

All groups executed the exercise program for 30 minutes with group 1 performing the exercises without any interventions. The second group took Mefenamic acid 30 minutes prior to the start of the exercise program. A low intensity TENS (50-100 Hz, 50-200 µs pulse width) and a high intensity TENS (2-4 Hz, 100-400 µs pulse width) were applied for groups 3 and 4, respectively, for 20 minutes prior to and subsequent to exercise. Numerical Pain Rating Scale (NPRS) was used to measure the intensity of muscle pain following a 24-hour period of exercises. Also, the time duration before onset of muscle soreness was recorded for each group.

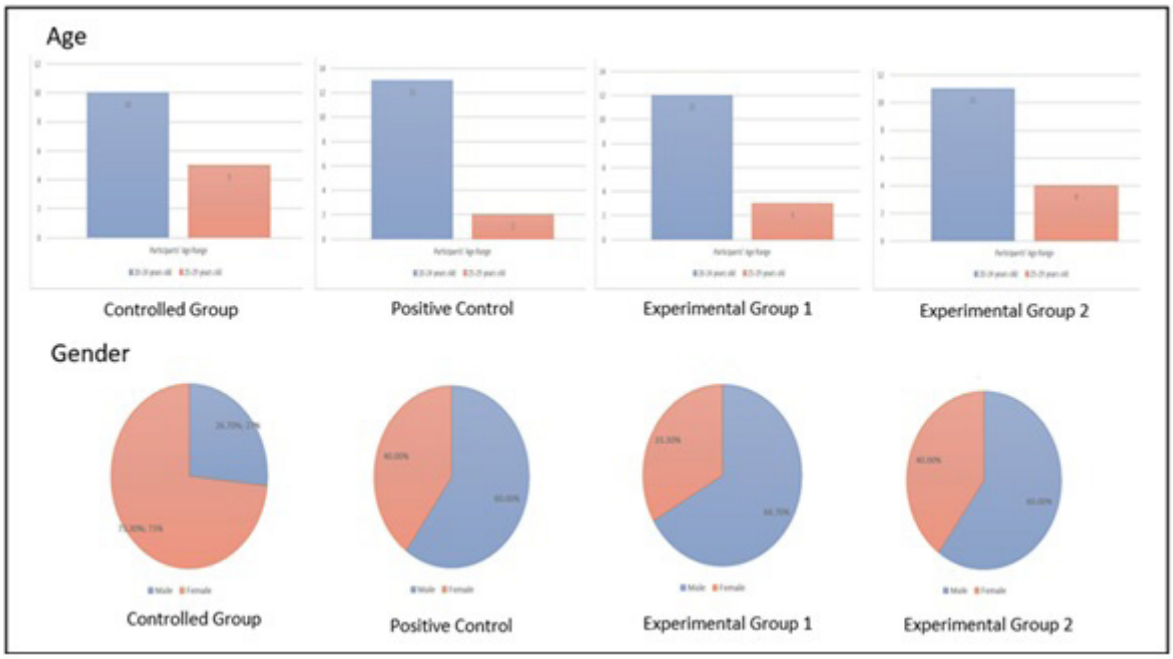
Statistical Analysis

Mean difference and p-value are computed for all the dependent variables. Data for each dependent measure were analyzed with ANOVA. Using Scheffe's post-hoc tests, significant differences between and within groups were measured with p – value set at 0.05.

RESULTS AND DISCUSSION

Data analysis was obtained using STATA (ver.9, 1984 – 2005). One way analysis of variance and Scheffe's post-hoc were used to determine the variance and mean significance among the variables.

Figure 1. Demographic Profile of Participants from 4 Groups.



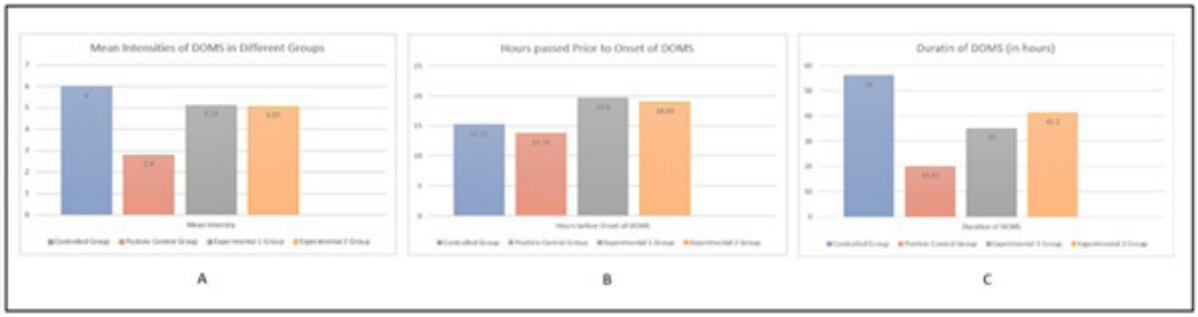
Legend. Age = 20-24 years old, 25-29 years old. Gender = Male, Female.

Demographic Profile

Figure 1 depicts the demographic profiles of the participants according to gender and age group. Comparison of gender and age of the participants in every group were also shown. The graphs show that male population dominates the total number of participants with the largest age group belonging to 20 to 24 years old.

Pain Intensity, Onset, and Duration of DOMS

Figure 2. Pain Intensity (A), Onset (B), and Duration of DOMS (C) from 4 Groups



Legend. Controlled Group, Positive Control Group, Experimental 1 Group, Experimental 2 Group; ***A= Mean Pain Intensities of DOMS, B= Onset of DOMS, C = Duration of DOMS.***

Figure 2 shows the differences in pain intensity (using NPRS), onset (in hours), and duration (in hours) of DOMS between the 4 groups. Graph A depicts that the control group has the highest mean pain intensity of 6, while the positive control group has the lowest mean pain intensity of 2.8. Notably, experimental groups 1 and 2 have a relatively similar mean pain intensity (5.13 and 5.07, respectively) with a difference of only 0.06.

Graph B shows noticeable difference in the hours elapsed in the control group and the experimental groups. Interestingly, It took a longer time for DOMS to occur in experimental groups 1 and 2 (19.6 and 18.93 hours, respectively) yielding to significant difference between them (p- value=0.008; **Table 1-B**), compared to the negative control group (15.13 hours), and the positive control group displaying the shortest time of onset of DOMS at 13 hours.

The experimental groups showed a shorter duration of DOMS (E1=35 hours; E2=41.2 hours) when compared to the negative control group (56 hours). The positive control group indicated the shortest duration of DOMS at 19.93 hours (**Figure 2**, Graph C). Aside from the insignificant difference in the experimental groups (p-value= 0.433), remaining group comparisons revealed significant differences in the duration of DOMS with p-values < 0.05 (**Table 1-C**).

DISCUSSION

TENS is a non-pharmacological intervention that activates a complex neuronal network to reduce pain and hyperalgesia (Vance et al., 2015). In addition, using the comfortable strongest intensity, it produces hypoalgesia in healthy subjects but lower intensities seemed ineffective (Osiri, 2000).

TENS can be applied with varying frequencies, from low (<10 Hz) to high (>50 Hz) and from sensory to motor intensities (DeSantana et. al, 2008). A combination of low intensity, high frequency (>100Hz), and a short pulse duration (50-80μs) stimulates Group II (Aß) afferent nerve fibers that produces short analgesia lasting for only up to few hours post - treatment (Walsh, 1997). Painless induced contractions as effects of burst TENS may relieve pain in the same way as sensory-level stimulation (via pain gates) (Macedo et al., 2014).

The results of the recent study revealed that subjects applied with TENS (experimental 1 and 2) showed mean pain intensities lower than the negative control group but with higher pain intensities compared to the positive control group. Studies of Walsh (1997) and Macedo et al. (2014) emphasize the effects of varying parameters of TENS influencing pain perception. Application of maximally tolerated intensity noted a significant analgesic effects of TENS (Vance, et al., 2014). Moreover, the emergence of DOMS in the experimental groups were much delayed appearing only at an approximate average of 18 hours compared to the negative control group (15.13 hours).

Table 1. Statistical Comparison of Mean Pain Intensity (Table 1-A), Mean Hours before Onset (Table 1-B), and Mean Duration of DOMS (Table 1- C) in Different Groups.

Table 1-A. Statistical Comparison of Mean Intensities of DOMS in Different Groups.

Variables	Mean Difference	P - Value	Conclusion
Positive and Control	-3.2	0.000	Significantly Different
Experimantal 1 and Control	-0.87	0.274	No Significant Difference
Experimantal 2 and Control	-0.93	0.214	No Significant Difference
Experimantal 1 and Positive	2.33	0.000	Significantly Different
Experimantal 2 and Positive	2.67	0.000	Significantly Different
Experimantal 2 and Experimantal 1	-0.067	0.999	No Significant Difference

Table 1-B. Statistical Comparison of Mean Hours before Onset of DOMS in Different Groups.

Variables	Mean Difference	P - Value	Conclusion
Positive and Control	-1.4	0.818	No Significant Difference
Experimantal 1 and Control	3.8	0.090	No Significant Difference
Experimantal 2 and Control	-1.56	0.774	No Significant Difference
Experimantal 1 and Positive	5.2	0.009	Significantly Different
Experimantal 2 and Positive	-0.16	1.000	No Significant Difference
Experimantal 2 and Experimantal 1	-5.36	0.008	Significantly Different

Table 1-C. Statistical Comparison of Mean Duration of DOMS in Different Groups.

Variables	Mean Difference	P - Value	Conclusion
Positive and Control	-36.07	0.000	Significantly Different
Experimantal 1 and Control	-21	0.000	Significantly Different
Experimantal 2 and Control	-14.8	0.000	Significantly Different
Experimantal 1 and Positive	15.07	0.002	Significantly Different
Experimantal 2 and Positive	21.27	0.000	Significantly Different
Experimantal 2 and Experimantal 1	6.2	0.433	No Significant Difference

The positive control group presented the shortest mean duration of DOMS (19.93 hours). NSAIDs reduce inflammatory response in the muscle leading to decreased muscle edema and intramuscular pressure, which contribute to pain and muscle soreness (Cheung et al., 2003). Conversely, experimental 1 has a shorter duration of DOMS (35 hours) than Experimental 2 Group (41.2 hours). TENS stimulates large diameter afferent fibers that activate descending inhibitory system to reduce hyperalgesia, thus lessening pain duration (Vance et al., 2014). Application of TENS results to decreased pain and an early increase of range of motion in affected area (Jason et al., 1996). Also, muscle sore duration depends on how an individual keeps the muscle in motion, with light exercises, providing relief and helps body to adapt (Sarnataro, 2006).Presently, there are limited studies that provide evidence of TENS as prophylaxis against DOMS. In the current study, TENS has the potential to prevent DOMS in a manner that significantly reduced the number of hours DOMS is experienced compared to participants without intervention.

CONCLUSION AND RECOMMENDATIONS

DOMS generally occurs between 24 to 72 hours after a session of unaccustomed exercise. On the other hand, TENS is used to alleviate muscle soreness, tightness and even painful spasms. It serves as analgesic for muscle pains and assists in improving muscle blood flow during exercise. There have been no studies recorded yet regarding the preventive effects of TENS on DOMS.

Application of TENS on quadriceps and gastrocnemius muscles before and after an endurance exercise did not prevent the occurrence of DOMS. Nevertheless, it lessened the intensity of muscle pain perceived, delayed the onset of DOMS, and significantly reduced the duration of DOMS in the participants (**Figure 3 – Table 3**).

The study was conducted during the pandemic crisis thus limiting the number of participants of the study. Further studies should delve on increasing the number of participants and including a wide age range, focus on other muscle groups, and using different parameters of TENS for reliability and validity of results.

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