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Effect of transcutaneous electromyostimulation on pressure pain threshold and tolerance in athletes under eccentric exercise

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Abstract

Exercise-induced hypoalgesia typically reported during and / or following exercise. In this study, we investigated the role of transcutaneous electromyostimulation (EMS) on pressure pain threshold and tolerance in athletes under eccentric exercise. Eleven male athletes aged 23,125 ± 0,99 years with 10,25 ± 2,66 years of athletic training were recruited for this study. Following baseline measurements of pressure pain threshold and tolerance from m. biceps brachii and m. triceps brachii muscle and myofascial regions of the dominant upper extremity by using a digital algometer, subjects were underwent an acute bout of eccentric exercise. Participants were completed 4 sets of eccentric exercise each comprising 20 repetitions of lifting 80% of their 1 RM by using a dumbbell. Pressure pain threshold and tolerance tests were repeated 10, 20 and 30 minutes, and 24 and 48 hours following exercise. One week after acute exercise protocol, EMS protocol was applied to the participants immediately following eccentric exercise, and all measurements were repeated at the same timeline as eccentric exercise. Standard EMS protocol at active recovery mode for 10 minutes was applied to the m. biceps brachii muscle by using surface electrodes. Results are presented as mean + standarts deviation. Data of the same timeline were analyzed by using repeated measures of ANOVA followed by Tukey's post hoc test. A level of $p<0.05$ was accepted statistical significant. Eccentric exercise resulted to increase the pain tolerence in athletes, and EMS was found to decrease the pain tolerence 10 and 20 minutes at the muscle region, and 10 and 30 minutes, and 24 hours at the myofascial region of m. biceps brachii, 10 min and 24 hr from muscle region, 10 and 30 min and 24 hr from myofascial region of M. triceps brachii following acute bout of eccentric exercise. We concluded that EMS at active recovery phase mitigates the the hypoalgesic response following single bout of eccentric exercise.

Key Words: eccentric exercise, exercise-induced hypoalgesia, electromyostimulation, pain tolerance

Introduction

Delayed onset muscle soreness (DOMS) is described as an unpleasant sensation or pain after unaccustomed strenuous exercise, and is quite common in humans (Armstrong, 1984). The most characteristic symptom in DOMS is tenderness, a kind of mechanical hyperalgesia, in the exercised muscle. It usually reaches a peak some 24–48 h after exercise in humans and disappears within 3–7 days (Armstrong, 1984; Newham, 1988; Graven-Nielsen & Arendt-Nielsen, 2003). There is usually no spontaneous pain (Graven-Nielsen & Arendt-Nielsen, 2003).

Many researchers have investigated the various treatments to attemp to reduce the symptoms of the DOMS such as nutritional supplements, massage therapy, or physical rehabilitation therapy. In recent years, active recovery protocols become popular to relieve the symptoms after sportive performance. The most widely researched forms of recovery include active and passive recovery, with active recovery being more effective at temporarily reducing muscle soreness (Cheung 2003, Armstrong 1994). Current evidence suggests that active recovery is more effective than passive recovery across several different measures, both physiological and functional. Several studies have found active recovery to be more effective than passive recovery at lactate removal as well as certain functional measures following the recovery period such as improved swim sprint times, upper body Wingate tests, a special judo fitness test, and competing in another judo match (Franchini et al. 2009, Rashidi et al. 2010, Baldari et al. 2005, Neric et al. 2009).

Transcutaneous electrical muscle stimulation (EMS), has been studied to determine its effects on performance and muscle soreness after exercise. Current evidence incorporating EMS as part of a recovery period during sprint swimming has shown that EMS is more beneficial during the post-exercise recovery period than passive recovery. EMS reduced lactate levels 20 minutes post-exercise significantly better than passive recovery (Maffiuletti et al. 2009). Likewise, a study by Warren et al. examining recovery with baseball pitchers showed that EMS was the only condition that had a significant decrease in blood lactate accumulation (BLA) during the recovery period. There was no change in BLA for the active and passive recovery conditions. In addition, perceived recovery was best for the EMS and passive recovery conditions (Warren et al. 2011). EMS also increases the arterial blood flow (Rigaux 1996), increases the production of analgesic substances such as endorphins and encephalins (Holmgren 1975, Chapman 1977), leading to an elimination of muscular pain.

Pain perception in athletes is commonly believed to differ from pain perception in sedentary persons (Tesarz et al. 2012). It has been shown that athletes frequently continue to exercise in the face of severe injury. Several reports demonstrated that long-standing physical activity may alter pain perception and have often concluded that athletes possess higher pain thresholds and higher pain tolerance.Therefore, the purpose of this study was to investigate the effect of EMS on pressure pain threshold and tolerance following single bout of eccentric exercise in athletes. We repeated our measurements at rest, 24 and 48 hours of recovery period following exercise.

Methods

Participants

The study was conducted at Sport Science and Application Center of Akdeniz University. Eleven male athletes were participated into this study.

Eccentric exercise protocol

The participants were completed 4 sets of eccentric exercise, each comprising 20 repetitions of lifting 80% of their 1RM. The exercise protocol was applied to the dominant upper extremity by using a dumbbell in the chair. Shoulders of the players were supported and their elbows were positioned to 90° flexion. The players were asked to drop the dumbbell on the ground as such each repetition would end in 2 to 3 seconds. For the next repetition the dumbbell was brought to the starting position by the researcher (Serinken et al. 2013).

EMS Protocol

EMS protocol was administered by using the Compex MI Sport, US Muscle Stimulator (1045 v05- DJO, France) and lasted in 10 minutes. One electrode (5X5 cm) was placed at the proximal end of the biceps muscle and the other one was placed near the distal insertion sites of the biceps muscle on the dominant arm. The Compex was set to the “Active Recovery” mode and intensity levels were set based on participant preference. Subjects were asked to remain in sitting position wih 90° elbow flexion for the duration of the procedure. This Compex setting stimulates efferent motor neurons with a rectangular biphasic symmetrical wave form, that had a pulse width of 250 microseconds (1 microsecond=1026 seconds). The frequency of the pulses starts between 9 and 10Hz then progressively decreases by 1 Hz, automatically, every two minutes. As the frequency decreases, the pulses increase in amplitude to penetrate the muscle fibers more deeply (Lattier et al. 2004).

Assessment

Height was measured using an ultrasonic height measure (Soehnle-Waagen GmbH & Co. KG). Body weight, % fat, fat mass, free fat mass (FFM) and total body water (TBW) was measured with a Tanita Body Composition Analyzer (Model TBF-300 TANITA, Tokyo, Japan). Skinfold of dominant arm was measured by using calliper.

Pressure pain threshold (PPT) and pressure pain tolerance (PPTO) measurement

Pressure pain threshold and tolerance were measured via an algometer (FPIX 50,Wagner Instruments, Greenwich, CT). PPT and PPTO values of participants were obtained from muscle and myofascial region of dominant arm. Single measures of both threshold and tolerance were taken at 90-second intervals to prevent habituation (DeWall and Baumeister 2006, Orbach et al. 1997). PPT and PPTO measurements were repeated at rest, and during 10, 20, 30 min, 24 and 48 hr of recovery period following eccentric exercise and/or EMS.

Statistical analysis

Results are presented as means + SD. Statistical significance was assessed by repeated measures of ANOVA followed by Tukey s post hoc test. A level of p<0.05 was accepted statistically significant.

Results

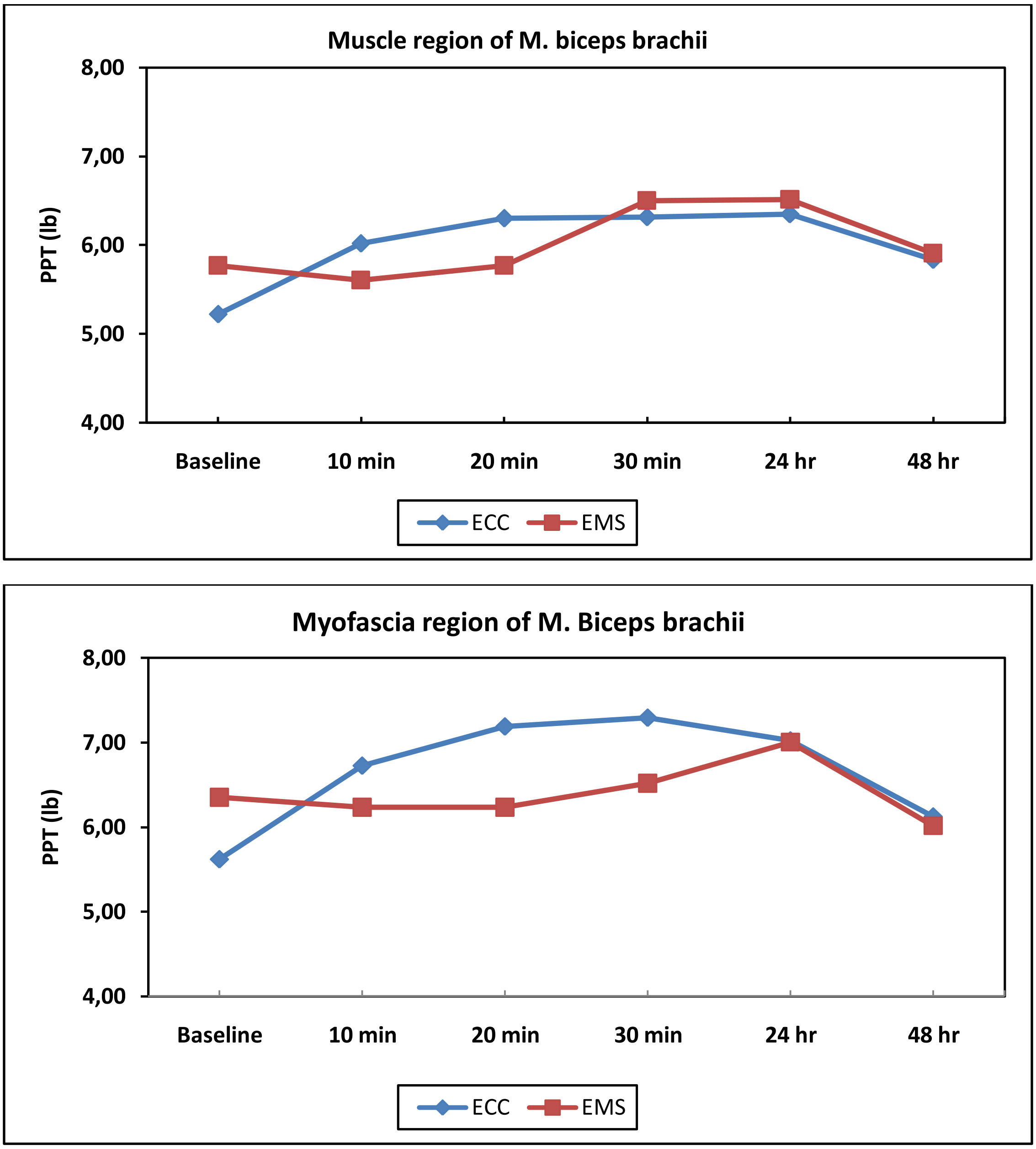
Table 1 summarizes the demographic caracteristics and body composition of the participants. The participants were young, had higher athletic training status and low fat mass according to the reference values of the general normative data (Pi-Sunyer 2000).

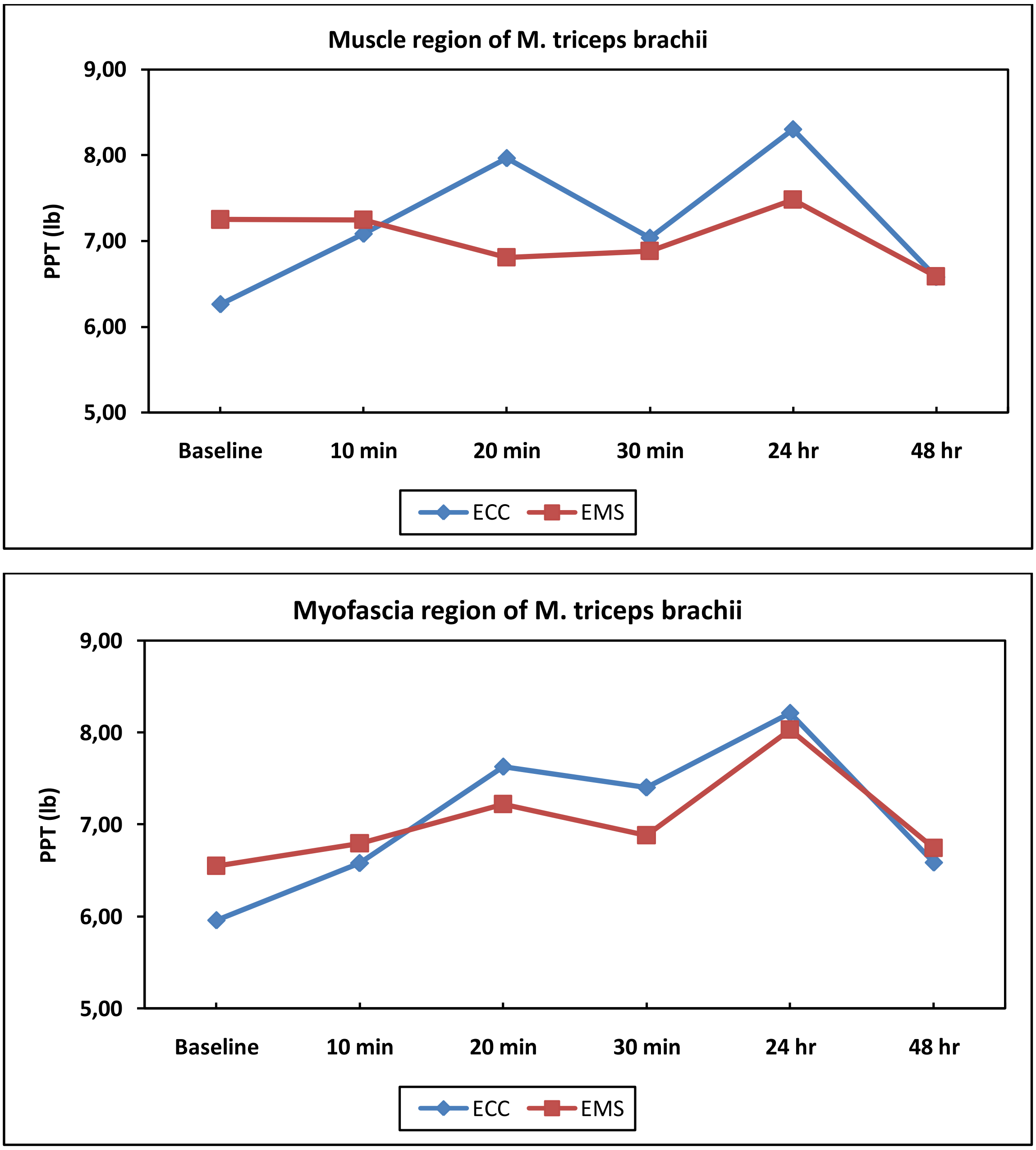
Table 1. Demographic characteristics and body composition of the participants

Age (years)	23,125 ± 0,99
Height (cm)	178,125 ± 7,77
Body weight (kg)	73,31 ± 7,64
Athletic training status (years)	10,25 ± 2,66
% Fat	9,24 ± 2.84

PPT and PPTO results obtained from four regions of dominant arm of two groups are presented in Figure 1 and 2. Although we did not found significant differences between ECC (eccentric exercise) and EMS on pain threshold as presented in Figure 1, eccentric exercise resulted to increase the pain tolerance from all regions of dominant upper arm at all time periods compared with the baseline and EMS values (p<0.05). On the other hand, EMS was found to decrease the pain tolerence at 10 and 20 minutes from muscle region of m. biceps brachii, 10 and 30 minutes, and 24 hours from myofascial region of M. biceps brachii, 10 min and 24 hr from muscle region, 10 and 30 min and 24 hr from myofascial region of M. triceps brachii following acute bout of eccentric exercise (Figure 2).

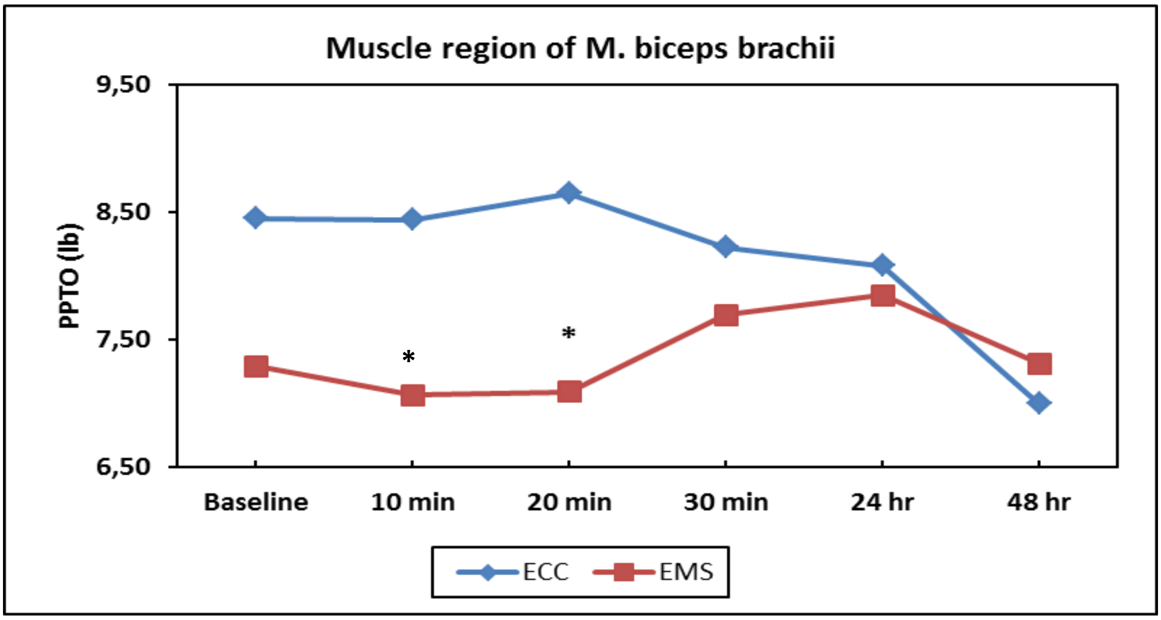
Figure 1. Average pressure pain threshold of muscle and myofascial regions of M. biceps and triceps brachii during rest, and following eccentric exercise, or EMS (lb)

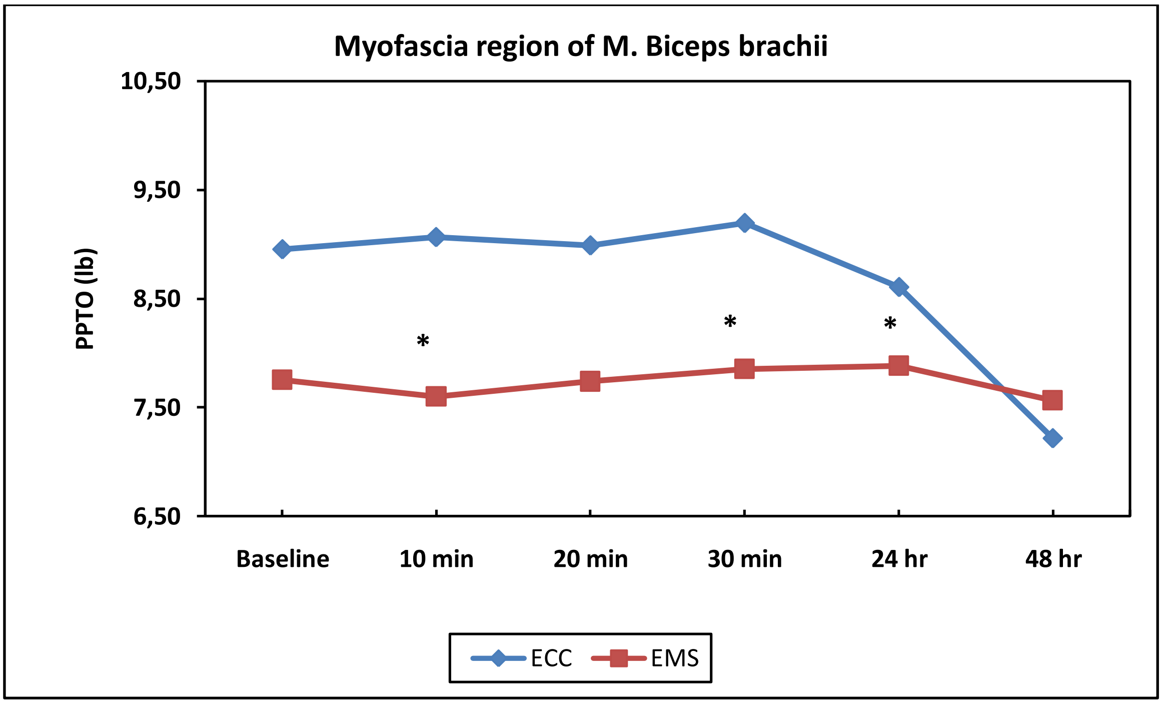


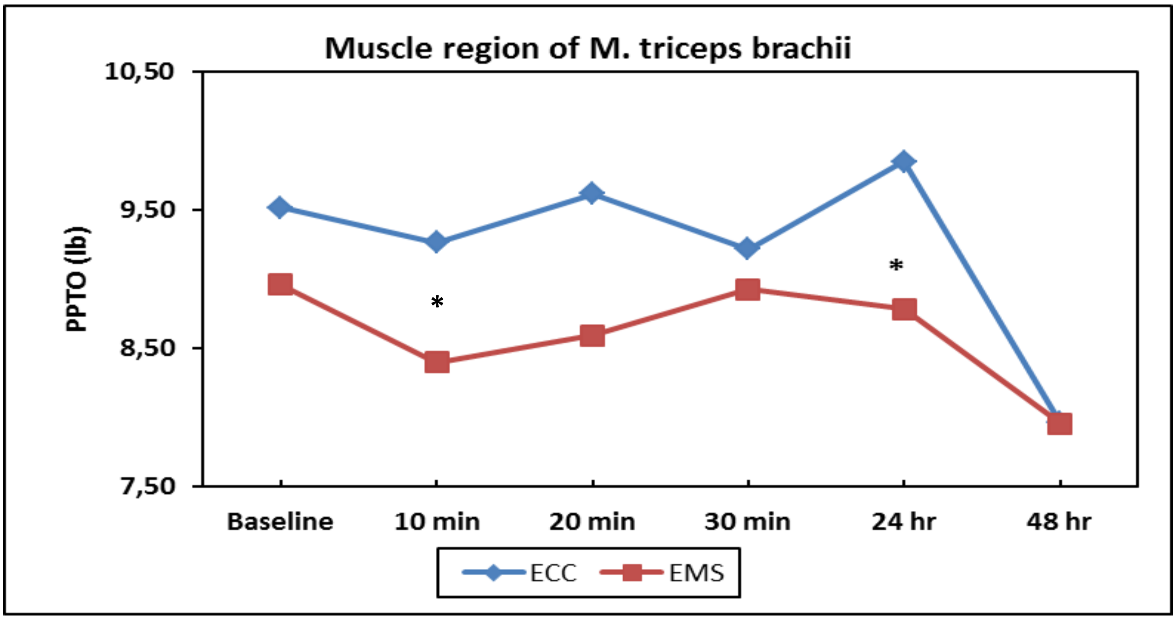


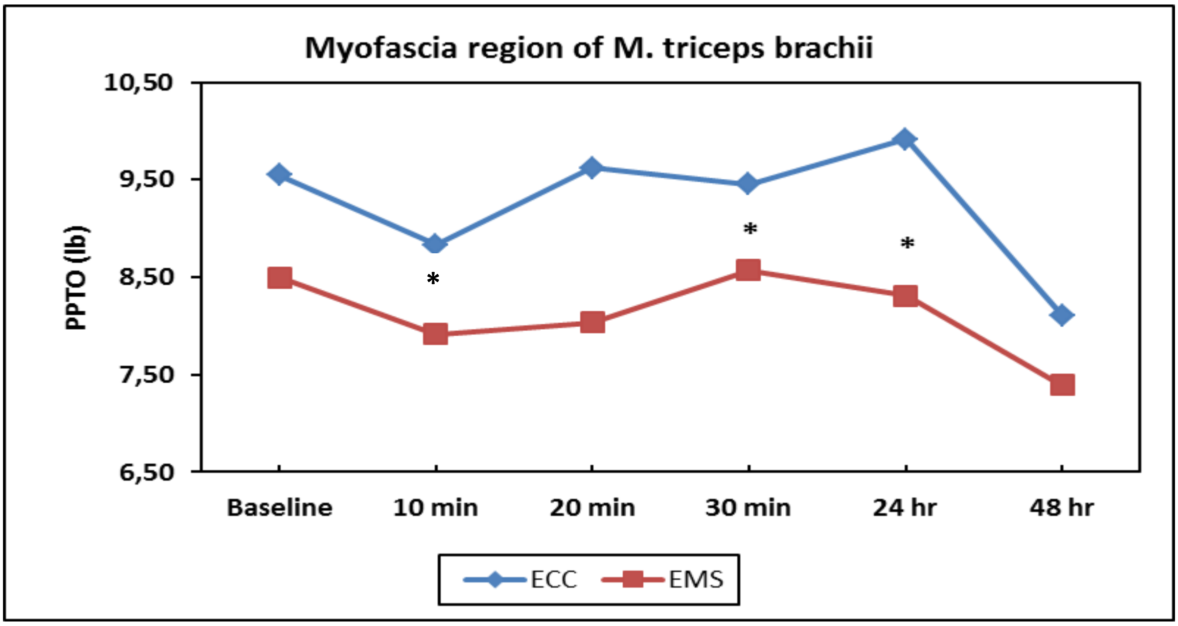
Values are expressed as mean + SD, n = 11 for each measurement. ECC: Eccentric exercise, EMS: Electromystimulation.

Figure 2. Average pressure pain tolerance of muscle and myofascial regions of M. biceps and triceps brachii during rest, and following eccentric exercise, or EMS (lb)









Values are expressed as mean + SD, n = 11 for each measurement. ECC: Eccentric exercise, EMS: Electromystimulation. *p<0.05, difference from corresponding ECC measurement.

Discussion

This study evaluated the effect of EMS on pain threshold and tolerance after single bout of eccentric exercise in athletes. The results of the present study demonstrated that EMS may have an impact on pain tolerance in post-exercise period. To our knowledge, this is the first study evaluating the effect of single EMS on pain tolerance alterations after acute eccentric exercise in athletes.

Demographic characteristics of the participants in the present study showed that the participants have low body fat and high athletic training years with 10,25 ± 2,66 years (Table 1). As a result, our participants are accepted as athletes. All athletes were played football throughout the athletic training lifetime.

In the present study, we did not find significant differences on pain threshold after eccentric exercise, or EMS. However, our results clearly demonstrated that single, acute eccentric exercise induces a hypoalgesic response throughout the 48 hr of recovery period following exercise (Fig 2). Our results are in accordance by the previous reports showing exercise-induced hypoalgesic response (Koltyn 2000, Ozkaya 2014). Several factors are suggested to play a role in exercise-induced hypoalgesia, including increased inflammatory response after exercise may release a variety of inflammatory mediators including reactive oxygen species (ROS), prostaglandin E2, leukotrienes, bradykinin, substance P, thromboxanes, inflammatory cytokines such as tumor necrosis factor (TNF)-α or interleukin (IL)-6, nerve growth factor, ATP and adenosine (Ambriz-Tututi et al. 2000, Kilic et al. 2014). Some of these agents are known to activate nociceptors, while others release local algogenic agents. We have also previously shown that exercise increases plasma melatonin concentration which has been known an analgesic substance in exercise trained animals (Ozkaya et al. 2014, Ozdemir et al. 2013), and endogenous melatonin is one of the candidate which may contribute the hypoalgesic response following exercise.

In the present study, EMS seems to be effective to restore the hypoalgesic response at 10 and 20 min in muscle region, and at 10, 20, 30 min and 24 hr following exercise in myofascial region of M. biceps brahcii. On the other hand, at the antagonist muscle, the decreased PPTO occurs at 10 min and 24 hr in muscle region, and 10, 30 min and 24 hr at the myofascial region.

The main use of EMS as a training modality allows preservation (Gibson et al. 1988) or recovery (Eriksson and Haggmark 1979) of muscle mass and function in patients, and improves muscle strength in healthy subjects (Bax et al. 2005) and athletes (Maffiuletti 2006). However, EMS has also been shown to evoke action potentials in both intramuscular nerve brances, cutaneous receptors and sensory fibers (Maffiuletti 2010). Our EMS protocol is applied to the dominant upper arm for 10 min duration. The frequency of the pulses starts between 9 and 10 Hz then progressively decreases by 1 Hz, automatically, every two minutes. As the frequency decreases, the pulses increase in amplitude to penetrate the muscle fibers more deeply (Lattier et al. 2004). In regard to the stimulation frequency, research in EMS showed that different stimulation frequencies activate different types of muscle fiber (Appell 1997). For example, in a fiber spectrum of 2–15 Hz, mostly slow-twitch fibers (type 1) would be stimulated. According to Appell (1997), fast-twitch fibers (type 2), which are responsible for the development of high forces, may not contract below 35 Hz. A further increase in frequency then leads to a complete tetanus of the stimulated muscle. Appell (1997) acts on the assumption that this maximal muscle activation can be enhanced up to a frequency of 70 Hz. However, there are different opinions about the level of stimulation frequency in the current state of research. Although Kramer (1984) achieved the highest Mmax with 20 Hz, Cometti (1998) recommends impulse frequencies from 50 to 100 Hz. Binder-Macleod and Guerin (1990) came to a similar result. They see higher frequencies between 60 and 100 Hz as more effective.

In the present study, we did not aimed to investigate the effect of the different stimulus frequencies on the force development of the muscle fibers, however, the results of our study clearly showed that the lower stimulation frequencies were effectively reduced the PPTO values after eccentric exercise. It has been previously shown that transcutaneous electrostimulation is a valuable theraphy in cases of chronic pain (Eriksson et al. 1979). Our results are also inconstintent with the previous findings indicating analgesic effect of electrostimulation due to increased beta endorphin release after electrostimulation (Akil et al. 1978, Holmgren 1975). Discrepancies between the present and previous studies may have been due to procedural differences. The present design departs significantly from prior studies in the selection of the participants, since our subject group was selected from healthy athletes which was distinctively differ from those patient group in the previous studies. In contrary, Gramly et al. (2012) found that there was no difference between recovery conditions for the hamstrings or calves with regard to perceived pain, as measured by the VAS (visual analog scale). However, after 48 hours, VAS for the quadriceps indicated improved outcomes for the active recovery condition. This contradicted the hypothesis that EMS recovery would result in decreased muscle soreness outcomes when compared to the active recovery condition. However, since EMS recovery was only used on the hamstring muscles than all other muscle groups, including the upper arm flexor and extensors. This result is consistent with a similar study that examined different recovery methods following preseason soccer training, and found both EMS and active recovery to reduce DOMS more effectively than passive recovery (Tessitore et al. 2007).

Several limitations in our study should be mentioned. Our participants were selected from the athletic group working on football for approximately 9 years. Further studies should be replicate by using the large number of groups of athletes working on different kinds of sports, and different EMS protocols to clarify the mechanisms and possible consequences of hypoalgesic effect between short- or long term spesific adaptations of the exercise training.

In conclusion, the results of the present study showed that single acute eccentric exercise result the hypoalgesic response at the dominant upper arm, whereas transcutaneous EMS reduces the response in athletes. Our data strongly suggest a possible role of electrical stimulation on pain tolerance following eccentric exercise in athletes.

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