Medicina Sportiva
Med Sport 14 (4): 199-203, 2010
DOI: 10.2478/v10036-010-0032-3

PULSED-MAGNETIC FIELD THERAPY DOES NOT INFLUENCE INDICES OF MUSCLE DAMAGE FOLLOWING ECCENTRIC EXERCISE: A PRELIMINARY STUDY

Jeremy Walsh[(A-F)], **Lauren Simonds** [(A-F)], **Peter M. Tiidus** [(A,D,E)]

Department of Kinesiology & Physical Education and Faculty of Science Wilfrid Laurier University, Canada

Abstract

Introduction: Pulsed magnetic field therapy (PMFT) is promoted as an intervention to enhance post-exercise muscle recovery and healing. However there is little experimental evidence to support claims of its efficacy.

Aim of the study: This study evaluated the ability of one commercially available form of pulsed magnetic field therapy to influence muscle force recovery and soreness sensation following exercise induced muscle damage.

Material and methods: Male and female subjects (n=36) were divided into 3 groups and either exposed to continuous PMFT, or placebo for the duration of the study or served as controls (no intervention following muscle damage). All groups performed eccentric biceps contractions and were assessed for muscle soreness as well as dynamic and isometric biceps muscle peak torque for up to 96 hours post-exercise

Results: All groups experienced significant ($P<0.05$) reductions in dynamic and isometric muscle torque as well as increased muscle soreness up to 96 hours post-exercise. No differences ($P>0.05$) in these indices of muscle damage and recovery were observed between any of the groups was observed at any of the measured time points.

Conclusions: There was no significant influence of PMFT nor was there any placebo effect on indices of post-exercise muscle damage and repair following eccentric exercise. Hence PMFT is ineffective in influencing muscle recovery or healing following exercise.

Key words: *Muscle damage, muscle repair, muscle soreness, magnetic field therapy, exercise*

Introduction

Many recreational and competitive athletes are turning to alternative or complementary medical treatments to try to address athletic injuries and to potentially help speed muscle recovery and repair following intense training. However, many of the claims about the effectiveness of various alternative medical treatments in speeding the healing of muscle damage and sports injuries have not been empirically validated with appropriate scientific testing [1].

One such alternative medicine modality is pulsed magnetic field therapy (PMFT). A commercially available form of PMFT claims to absorb and convert ambient electro-magnetic radiation into magnetic pulses, and then focusing these pulses onto specific body parts. Pulsed electro-magnetic fields are low-energy, time-varying magnetic fields which are also said to counteract potentially negative effects of ambient electro-magnetic "pollution". They differ from the more widely researched static magnetic fields in that they are of much lower intensity and are intermittent in nature [2]. Devices which claim to provide this type of PMFT are readily available for purchase over the internet and can be worn continually at the site of injury of muscle damage. Proponents of PMFT make numerous claims about its abilities for enhancing healing of damaged tissues, strengthening of the immune system and various other health related benefits [2,3]. Although various forms of magnetic therapy have a long and checkered history with claims of its effects to heal various disorders, going back several hundred years, there is little in the way of positive empirical data supporting their efficacy [3,4]. Magnetic therapy has also been suggested to diminish pain due to numerous health conditions, although again there is little in the way of experimental evidence to back up such claims and most studies report little or no effect of magnetic fields on pain perception [5,6]. Nevertheless, many professional and amateur athletes and teams have been reported to use various forms of magnetic therapy in the hopes on enhancing performance, speeding healing of injuries and reduction of muscle soreness and muscle damage [7]. However, one study which examined the effects of a short acute exposure to a static magnetic field following muscle damaging exercise found no effect of the treatment relative to placebo in regard to post-damage muscle swelling, soreness, strength recovery or stiffness over several days [7].

Many magnetic devices promoted to enhance tissue healing now claim to offer continual exposure to "pulsed magnetic fields" and are used by individuals in the hopes of, among other things, improving recovery from athletic injuries and muscle damage. Unlike static magnetic therapy which has to some extent been researched relative to exercise induced muscle damage (eg. 7) PMFT has not yet been extensively studied. There there been no studies examining the ability of continuous exposure to low levels of pulsed magnetic fields in the form of PMFT, at the site of injury or muscle damage on indices of muscle repair following damaging exercise. Hence, this study was designed to evaluate the effectiveness of one such commercially available product, the "Peace Disk" (MicroAlpha, Kitchener ON Canada) in influencing indices of muscle damage and recovery following exercise induced muscle damage.

Materials and Methods:

Subjects

All aspects of this study were reviewed and approved by the Wilfrid Laurier University Human Ethics Research Committee in accordance with the Helsinki Declaration. Subjects consisted of 36 healthy male (n=10) and female (n=26) participants between the ages of 17-24. All participants had refrained from any upper body resistance training 4 months prior to commencement of the study. All participants were screen for any underlying health issues via the PAR-Q questionnaire and provided written informed consent to participate.

Experimental Design

Participants were randomly assigned to one of three groups of 12 subjects each. Randomization was achieved by blind selection of subjects via drawing assigned subject numbers from an envelope by a third party. The groups did not differ significantly in age or sex distribution. The "control" group consisted of those subjects who had no intervention following muscle damaging exercise, the "functional" or experimental group who wore a functional pulsed magneto-therapeutic device on their biceps muscle for up to 96 hours following damaging exercise and "placebo" who wore a non-functional pulsed magneto-therapeutic device on their biceps muscle for up to 96 hours following damaging exercise. The subjects and testers were blinded to the identities of the placebo and functional group members. Previous power calculations based on published data using the same methodologies as the present study suggested that 10-12 subjects per group would provide more than 90% power (using a 2-side test with P =0.05) [6].

The experimental design is outlined in Figure 1. Participants individually attended 7 testing sessions over a 12 day span. Each testing session was approximately 10 -20 minutes in duration. During this time, participants were instructed to refrain from any resistance training and to avoid taking any non-steroidal anti-inflammatory drugs.

On the initial day (day 1) of the experiment bicep muscle dynamic and static peak torque force was determined in all subjects. One week later (day 8) the subjects performed the eccentric exercise induced muscle damaging protocol and were subsequently tested 24 hrs (day 9), 48 hrs (day 10) and 96 hrs (day 12) for static and dynamic biceps peak torque and delayed onset muscle soreness (DOMS) sensation.

The muscle damage protocols, as well as the static and dynamic force testing sessions were performed using the CYBEX NORM Testing and Rehabilitation

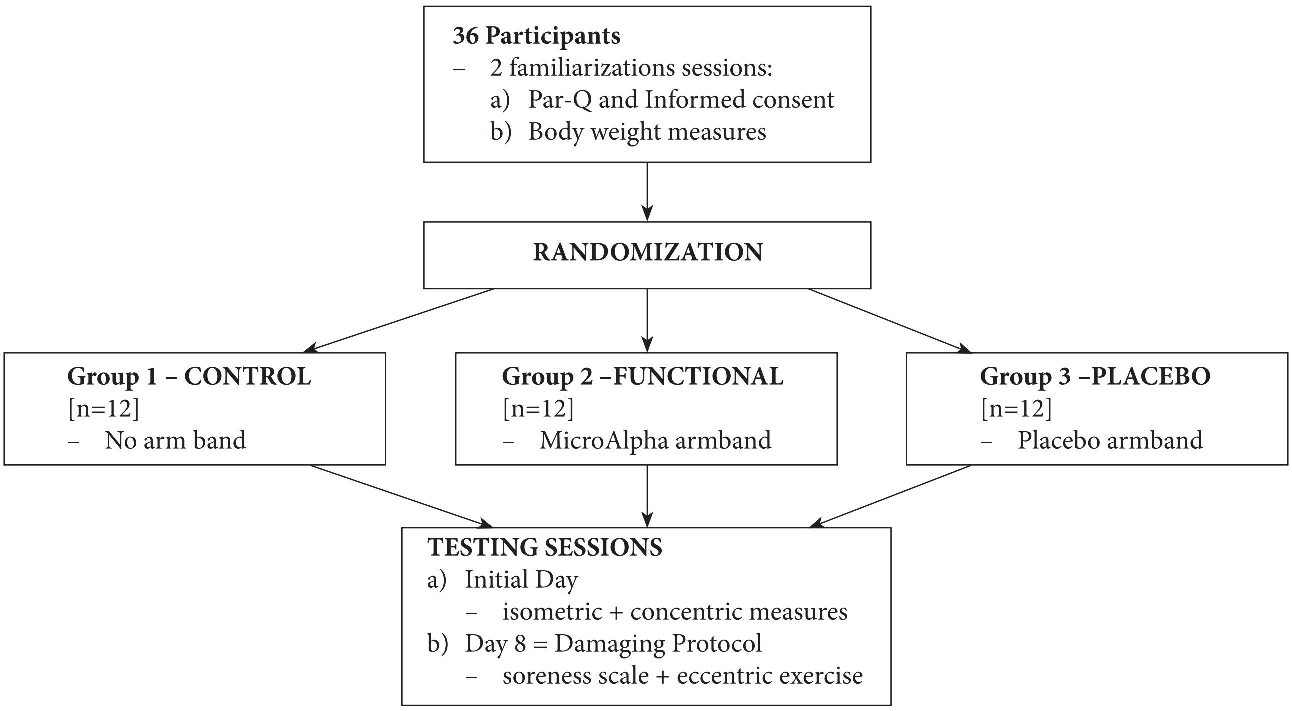

Fig. 1. *Flow chart outlining experimental design*

System within a controlled laboratory setting. The non-dominant arm **of** each participant was used for the experiment.

The muscle damaging protocol consisted of 6 sets of 10 maximal effort eccentric contractions (n = 60), using a constant lengthening velocity of 120°/sec with 45 seconds rest between sets. A similar muscle damaging protocol had previously been demonstrated to effectively induce muscle damage [8]. Researchers provided encouragement and feedback to participants during the testing to help maintain maximum effort.

The muscle force assessment protocol assessed peak isometric and concentric strength and took place prior to and at 24, 48 and 96 hrs following the muscle damage protocol. Isometric and dynamic measures of post-damage muscle force recovery are considered to be the most accurate non-invasive quantitative measures of muscle damage and recovery in human studies [9]. Isometric bicep strength was measured at 90° elbow flexion. Participants completed a total of 5 repetitions; 2 trial repetitions (sub-maximal effort) and 3 maximum voluntary contractions. Each repetition was held for 3 seconds followed by 10 seconds rest. Concentric bicep strength was measured using a constant contraction velocity of 60°/sec. Participants completed a total of 6 repetitions; 2 trial repetitions (sub-maximal) and 4 maximal repetitions; there was no rest between concentric contractions. The peak torque generated from both dynamic and static muscle force protocols was recorded in Nm/kg BW.

Delayed onset muscle soreness (DOMS) was also assessed at prior to and at 24, 48, and 96 hours following muscle damage. DOMS is also a commonly used semi-quantitative indicator of muscle damage and repair [9]. Prior to measuring strength, participants were asked to rate their biceps muscle soreness during voluntary movement at the given time points using a 'Soreness Scale' with 1 corresponding to "not sore at all" and 9 corresponding to "very very sore" [10].

Functional and placebo magneto-therapeutic disks (called "Peace Disks" by the manufacturer) identical in appearance and dimensions (5.25 cm x 1.6 cm), were provided by their manufacturer and distributor (MicroAlpha, Kitchener ON Canada). The manufacturer of the disks claimed that the functional devices collected ambient electro-magnetic waves and converted them to regularly pulsing extremely low magnitude electromagnetic frequency (EMF) which would bolster the immune system and speed healing of muscles when placed directly over them. It is described as an "Active electro-magnetic frequency neutralizer type-F" that absorbs man made electro-magnetic frequencies and converts them to magnetic pulses (www.microalpha.com). Further details on the specifics of this are proprietorial and not available to the public. Half of the disks contained the 'functioning' mechanism (Functional Disks). These disks were placed over the thickest part of the biceps muscle of the experimental arm of the subjects in the functional group immediately prior to the damaging exercise bout. The remaining disks did not contain a 'functioning' mechanism and therefore did not emit EMF; these units were used as Placebo Disks and worn by the placebo group. The disks were placed inside Nike iPod Nano –Video Armbands and worn directly over the damaged bicep. Researchers instructed participants on proper use and fitting of the armbands and emphasized the importance of maintaining adequate circulation to the entire limb. Participants were asked to wear the armbands at all times (except when showering) with the disk resting directly on the thickest part of the muscle belly of the biceps. Participants did not report any issues with wearing the devices.

Control group subjects did not wear any devices or receive any other interventions.

Statistical Analyses

Raw measures of strength were normalized by the HUMAC data collection program by dividing peak torque by each individual subject's body weight [kg]. Raw data were analyzed using a 3 x 4 Mixed Method Repeated Measures ANOVA to compare multiple levels of differences in isometric and concentric strength, as well as measures of soreness across the 4 days of testing. A Bonferroni Post Hoc test was used to test for significance and differences were considered statistically significant at $P < 0.05$. All data were normally distributed.

Results

Isometric muscle force measures

Results of peak isometric biceps muscle torque are depicted in Fig. 2. All groups experienced a significant a significant main effect of time ($P < 0.05$) with a significant ($P < 0.05$) decrease in isometric muscle force following a damaging bout of eccentric exercise, confirming that muscle damage was incurred. The greatest force loss was observed at 24 hr post-injury. Isometric muscle force gradually recovered as time progressed; however, there was still a marked deficit in force compared to baseline measures at 96 hrs post-damage. There was no significant difference between any of the groups (functional, placebo or control) in recovery of isometric biceps muscle strength following a damaging bout of eccentric exercise.

Concentric muscle force measures

Results of peak concentric biceps muscle torque are depicted in Fig. 3. All groups experienced a significant main effect of time ($P < 0.05$) with a significant ($P < 0.05$) decline in concentric bicep force following a damaging bout of eccentric exercise. Similar to isometric force,

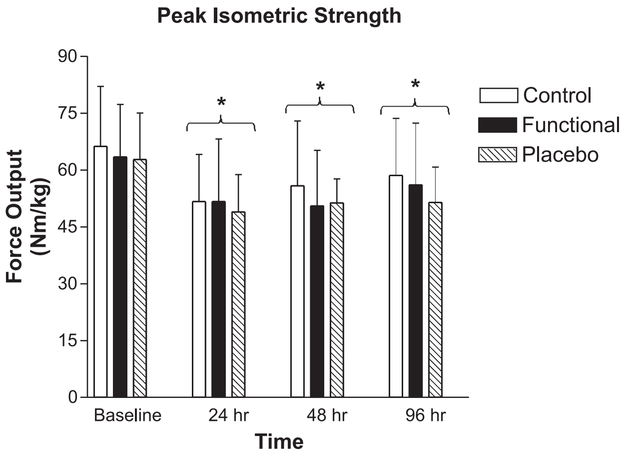

Fig. 2. *Mean peak isometric biceps muscle torque measured at baseline (pre-injury), 24 hr, 48 hr, and 96 hr post-damage. * represents a significant decrease in force among all participants compared to baseline measures (P < .05). There is no significant difference (P >0.05) between the control, functional or placebo groups at any of the time points*

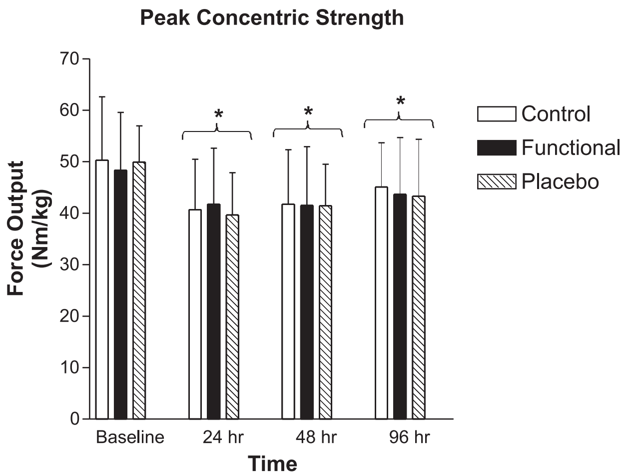

Fig 3. *Mean peak concentric (60 degrees/sec) biceps muscle torque measured at baseline (pre-injury), 24 hr, 48 hr, and 96 hr post-damage. * represents a significant decrease in force among all participants compared to baseline measures (P < .05). There is no significant difference (P > 0.05) between the control, functional and placebo groups at any of the time points*

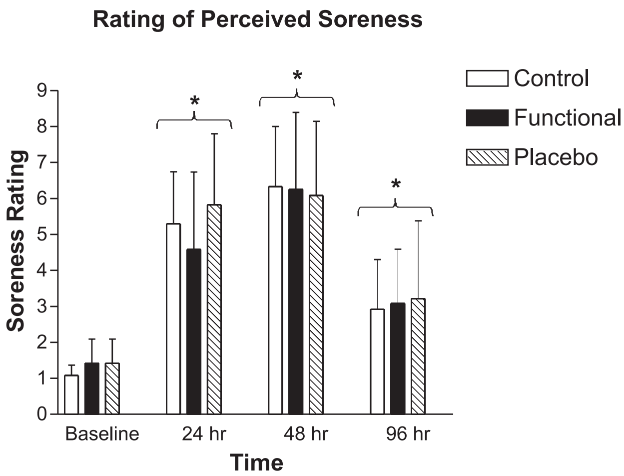

Fig. 4. *Mean rating of perceived soreness (DOMS) measured at baseline (pre-injury), 24 hr, 48 hr, and 96 hr post-damage. * represents a significant increase in perception of soreness among all participants compared to baseline measures, P < .05. There were no significant differences between control, functional and placebo groups (P > 0.05) at any of the time points*

the greatest decrease in concentric force was observed at 24 hr post-injury. There was no significant difference between groups (control, functional or placebo) at any time point in the recovery of concentric force of the biceps following a damaging bout of eccentric exercise.

Soreness Measures

Results of DOMS measures are depicted in Fig. 4, Compared to baseline measures, all groups experienced a significant a significant main effect of time ($P < 0.05$). There was a significant ($P < 0.05$) increase in the participant's perception of muscle soreness following a damaging bout of eccentric exercise in all groups. The greatest reported soreness was observed to at 48 hr post-injury. There were no significant differences ($P > 0.05$) between any of the groups (functional, placebo or control) in the perception of muscle soreness at any time point following a damaging bout of eccentric exercise.

Discussion

This is the first study to demonstrate that low level continuous pulsed magnetic field therapy (PMFT) applied for up to 96 hours following damaging exercise directly to the damaged muscle does not affect the rate of recovery of isometric or dynamic muscle force or DOMS. Further, there were no placebo effects of this intervention as evidenced by a lack of difference in recovery of muscle force or DOMS measures for up to 96 hours following damaging exercise.

The eccentric protocol used in this study effectively induced significant muscle damage, evidenced by the significant decrease in both isometric and concentric force following the damaging bout of exercise and increase in DOMS in all groups of subjects. The greatest decline in isometric and concentric force for all groups was observed 24 hours post-injury. These time courses are consistent with those reported in previous studies describing exercise induced muscle damage and repair [eg 8, 11].

Muscle force recovery following exercise induced muscle damage is the single most accurate assessment tool to determine the degree of muscle damage and the rate of muscle repair [8] and is used regularly in studies assessing the effectiveness of interventions in treating exercise induced muscle damage in humans [12]. Hence, the lack of effect of continuous PMFT in altering the recovery of isometric or dynamic muscle force for up to 96 hours following damaging exercise relative to placebo or control groups suggests that this form of treatment as utilized in this study is ineffective in altering the rate of natural muscle healing. The physiology of exercise induced muscle damage and healing has been well documented from both animal and human studies and involves an initial post-damage inflammatory response followed by repair associated with muscle satellite cell activation [13]. Although suggestions have been made that PMFT may influence muscle immune and inflammatory responses, there are no known physiological mechanisms by which pulsed magneto-therapy would actually influence the degree of exercise induced muscle damage or the rate of muscle healing. The results of this study would suggest that no such mechanisms exist.

It has also been suggested that the electromagnetic frequencies emitted from these devices can act to disrupt afferent input from free nerve endings of nociceptors, therefore reducing the perception of pain [14]. However, under the conditions of this study, PMFT did not have any influence on the degree of DOMS at any point up to 96 hours following a damaging bout of eccentric exercise. Additionally, the placebo devices did not appear to have any psychological influence on the perception of pain for individuals in the placebo group relative to the control group as both groups experienced similar DOMS sensation.

Previous studies involving static magnetic fields have also produced similar results. A previous study that examined effects of a short acute application of a strong magnetic field to the affected muscle following muscle damage have yielded the same negative results in muscle force recovery, DOMS and other indices of muscle damage and recovery up to 72 hours post-damage [7]. Two other studies also involving static magnets worn for 3-7 days following exercise induced muscle damage over the affected muscle have also reported no effect on DOMS isometric strength recovery or muscle swelling [15,16]. Static magnetic fields have also been reported to have no influence on perception of ischemic muscle pain or sympathetic nerve activity in healthy subjects [6]. Hence other forms and application durations of magneto-therapy have also failed to demonstrate any positive effects of this type of intervention in the normal time course of indices muscle healing or soreness sensation following damaging exercise.

Although many other health and pain reduction related claims have been made for various other forms of magneto-therapy, the vast majority of studies have also failed to verify these claims [4,5,7].

The findings of this study, which examined a unique form of electro-magnetic therapy (PMFT) is in line with most of the previous literature. Hence, based on the findings of this study, pulsed magnetic field therapy [PMFT] cannot be recommended for athletes or other active individuals as a means for enhancing muscle recovery or repair or as an analgesic for DOMS sensation following exercise induced muscle damage.

Acknowledgments

This study was supported by research funds from the STEP Council of Science Faculty of Wilfird Laurier University.

References

1. Ernst E. [ed]. Complementary medicine, an objective appraisal. Oxford UK: Butterworth-Heineman, 1996.
2. Bassett CA. Fundamental and practical aspects of therapeutic uses of pulsed electromagnetic fields [PEMFs]. *Crit Rev Biomed Eng* 1989; 17: 451-529.
3. Flamm BL. Magnet therapy: Healing or Hogwash? *Anesth Analg* 2007; 104: 249-50.
4. Basford JR. A historical perspective of the popular use of electric and magnetic therapy. *Arch Phys Med Rehabil* 2001; 82: 1261-9.
5. Flamm BL. Magnet therapy; extraordinary claims but no proven benefits. *Br Med J* 2006; 332: 4-5.
6. Kuipers NT, Sauder CL, Ray CA. Influence of static magnetic fields on pain perception and sympathetic nerve activity in humans. *J Appl Physiol* 2007; 102: 1410-5.
7. Reeser JC, Smith DT, Fischer V, et al. Static magnetic fields neither prevent nor diminish symptoms and signs of delayed onset muscle soreness. *Arch Phys Med Rehabil* 2005; 86: 565-70.
8. Stauber WT, Clarkson PM, Fitz VK, et al. Extracellular matrix disruption and pain after eccentric muscle action. *J Appl Physiol* 1990; 69: 868-74.
9. Warren GL, Lowe DA, Armstrong RB. Measurement tools used in the study of eccentric contraction-induced injury. *Sports Med* 1999; 27: 43-59.
10. Tiidus PM, Ianuzzo CD. Effects of intensity and duration of muscular exercise on delayed soreness and serum enzyme activities. *Med Sci Sports Exerc* 1983; 15: 461-5.
11. Howell, JN, Chleboun G, Conatser R. Muscle stiffness, strength loss, swelling and soreness following exercise-induced injury in humans. *J Physiol* 1993; 464: 183-96.
12. Warren GL, Palubinskas LE. Human and animal experimental muscle injury models. In: Tiidus PM ed. Skeletal muscle damage and repair. Champaign IL Human Kinetics Inc 2008: 13-35.
13. Tiidus PM ed. Skeletal muscle damage and repair. Champaign IL Human Kinetics Inc. 2008.
14. Weintraub MI, Wolfe GI, Barohn RA et al. Static magnetic field therapy for symptomatic diabetic neuropathy: A randomized, double-blind, placebo-controlled trial. *Arch Phys Med Rehabil* 2003; 84: 736-46.
15. Borsa PA, Liggett CL. Flexible static magnets are not effective in decreasing pain perception and recovery time after muscle micro-injury. *J Athl Train* 1998; 33: 150-5.
16. Mikesky AE, Hayden MW. Effect of static magnetic therapy on recovery from delayed onset muscle soreness. *Phys Therapy Sport* 2005; 6: 188-94.

Received: July 27, 2010
Accepted: November 10, 2010
Published: November 23, 2010

Address for correspondence:
Peter M.Tiidus, Ph.D.
Professor, Department of Kinesiology & PE
Wilfrid Laurier University,
75 University Ave W.
Waterloo ON Canada N2L 3C5
Phone: 519-884-0710 ext. 3276, 519-747-4594 [fax]
E-mail: ptiidus@wlu.ca

Jeremy Walsh: jeremywalsh16@gmail.com
Lauren Simonds: laurensimonds27@hotmail.com