CAN MICROCURRENT ELECTRICAL NEUROMUSCULAR STIMULATION DECREASE SYMPTOMS ASSOCIATED WITH DELAYED ONSET MUSCLE SORENESS?

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We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality of a thesis for the degree of Master of Science in Kinesiology and Leisure Science.

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Introduction

Traumatic injury typically presents with the five cardinal signs of inflammation secondary to the release of histamine and norepinephrine. These chemical mediators increase capillary permeability, allowing exudate high in proteins and leukocytes, and phagocytic cells to destroy, and marginize damaged tissue. Injured tissues are electropositive but become electrical negative in the early stages of the healing process. These processes are dependent on membrane permeability and active transport across the cell membrane (Prentice, 1999; Starkey, 1999) Active transport theoretically increases with microcurrent electrical neuromuscular stimulation (MENS) thereby re-establishing the body's natural electrical balance resulting in adenosine triphosphate (ATP) replenishment and providing the metabolic energy necessary for healing to occur (Starkey). The biophysical efficacy of MENS (< 500 μA) is based on the theory that currents less than 500 μA increase ATP levels while currents greater than 500 μA decrease ATP levels. Currents less than 500 μA create a proton imbalance forcing them across the mitochondrial membrane, as they move from anode to cathode, causing an increase in the production of ATP (Baily, 2003; Starkey, 1999).

Successful treatment of fracture and wounds using MENS is well documented (Assimacopoulos, 1968; Carley & Wainapel, 1985; Feedar *et al.*, 1991; Gault & Gatens, 1976; Gentzkow *et al.*, 1991; Mulder, 1991; Wolcott *et al.*, 1969; Wood *et al.*, 1993) These studies involved placing the cathode directly over the fracture site or ulcer in wound healing (Brighton *et al.*, 1981; Connolly *et al.*, 1997; DC Paterson *et al.*, 1982). Conversely, MENS treatment of delayed onset muscle soreness (DOMS) is inconclusive,

controversial, anecdotal and limited(Allen *et al.*, 1999; Bonacci & Higbie, 1997; Lambert *et al.*, 2001; Weber *et al.*, 1994) Delayed onset muscle soreness is a soft tissue injury characterized by the disruption of the cell membrane and active transport system resulting in decreased ATP production and streaming of the Z-lines in type IIB muscle fibers (Friden, 1984; Newham *et al.*, 1983). All but one (Lambert et al., 2001) of the aforementioned studies involved treatment with alternating polarity (Bonacci & Higbie, 1997; Denegar *et al.*, 1992; Weber et al., 1994) or didn't specify (Allen et al., 1999) over the injury site during the treatment period. Conversely, Lambert was the only investigator who placed the cathode (negative) over the injury site. Additionally, Lambert and Bonacci utilized extended treatment periods (96 continuous hours, 8 continuous hours, respectively).

Therefore the purpose of this study was to examine the effect of MENS treatment protocols typically used in athletic training clinical practices with specific attention to polarity. The hypothesis for this study was that there will be no difference among MENS treatments relative to pain, edema, and range of motion and muscle strength associated with DOMS.

Method

Subjects were 60 healthy male (28) and female (32) volunteers age 18-32 years. Prior to participation all subjects were screened for general medical and upper extremity pathologies via two separate questionnaires by a sports medicine team physician and subjects completed informed consent forms (Appendix B) approved by the University's Committee on Human Studies (Appendix B).

Research Design

Influence of MENS on DOMS was assessed via a double-blind placebo protocol. Independent variables were: MENS healing (.3Hz), MENS pain (30Hz), MENS sham, and control groups. Control involved random selection of treatment and control arms. Dependent variables were: perceived pain, palpable tenderness, biceps brachii circumference, resting joint angle, and isometric force production. Delayed onset muscle soreness was induced bilaterally via eccentric biceps brachii muscle activity on the Biodex Multi-joint System 3 dynamometer (Biodex Medical Systems, Shirley, NY).

Procedures

Double-Blind Protocol

Data were collected and treatments were administered on five consecutive days by two investigators who are both National Athletic Trainers' Association Board of Certification (NATABOC) certified athletic trainers. The data collector was responsible for collecting all dependent variable measurement data and was blinded to subject treatment protocols. The treatment administrator induced DOMS and administered the

MENS treatments to all subjects. Subjects were asked not to use pain medications and to refrain from changing or beginning new exercise activities during the study. Additionally, subjects were instructed to drink eight to ten 8 oz. glasses (64 oz.) of water per day to optimize MENS treatment success.

DOMS Inducement

The Biodex Multi-Joint System 3 Dynamomter (Biodex 3) (Biodex Medical Systems, Shirley, NY) was used to eccentrically induce DOMS bilaterally to the biceps brachii via 15 sets of 15 repetitions at 60 degrees/second with a one minute rest period between sets. Eccentric workload was established as twice the subjects' dumbbell curl one repetition maximum (1-RM) based on Dean (Dean, 1988)who reported that maximum eccentric force production was 14%-50% higher than concentric contraction of the same muscle.

Subjects were positioned and tested on the Biodex System 3 according to the manufacturer's recommendations. The starting position for the elbow was measured with a goniometer and set at 0 degrees of elbow extension to ensure consistency across all subjects. Elbow flexion range of motion (ROM) was limited to a total of 90 degrees for eccentric exercise. Resistance (torque) was set at the eccentric 1-RM and was initially reduced by 10 ft-lbs when subjects could not perform eccentric work through the entire range of motion. As fatigue ensued, torque was adjusted so that eccentric work could be completed throughout the designated elbow ROM. Following each eccentric extension, the treatment administrator returned the elbow to the flexed position to eliminate concentric biceps activity.

Microcurrent Treatment Protocol

Microcurrent electrical neuromuscular stimulation treatments were applied via three Vectra 2S electrical stimulation units (Chattanooga Group Inc., Hixson, TN). The manufacturer disabled one of the units to provide the sham treatment. Treatments for all groups were given five minutes after inducing DOMS and again at 24, 48, 72, and 96 hours. Prior to each treatment, subjects' upper extremity sensory threshold was determined via gradually increasing MENS intensities (without exceeding 600microamps) until the subject acknowledged an electrical sensation (prickling and/or tingling) in any electrode. The intensity was recorded and used to maintain treatment of the selected upper extremity at a sub-sensory level.

Treatments were applied via four 2 x 2 inch self-adhesive electrodes (Chattanooga Group, Inc., Hixson, TN) in the two and three dimensional placement configurations. The two dimensional protocol consisted of electrode placement over the long head of the biceps brachii origin and over the biceps brachii and brachialis insertions. The three dimensional protocol consisted of electrode placement over the bellies of the biceps brachii and triceps brachii. Skin resistance was minimized via vigorous cleaning of the application sites with alcohol swabs. Each subject used the same electrodes for the five treatment days. The Healing Group received MENS at .3Hz, applied at 40 μA. The Pain Group received MENS at 30Hz, applied at a sub sensory level and set at the highest possible intensity between 100 and 600 μA. All groups received 40 minute MENS treatments or sham MENS treatments with negative polarity. The Sham Group received MENS via a manufactory disabled unit to prevent an electrical current from passing through the channels. The control arm received no treatment.

Data Collection

Dependent variable data were collected before and after DOMS inducement and MENS treatments at 24, 48, 72, and 96 hours on five consecutive days. These data were collected in the following order to prevent confounding the results: perceived pain, resting joint angle, circumference, muscle tenderness, and isometric force. Data collection reliability and researcher bias were controlled by marking the measurement sites with permanent ink, for tenderness, circumference, and joint angle assessment and utilization of new data collection sheets for repeated tests, respectively.

Perceived pain was assessed with a Visual Analog Scale (VAS). The VAS is a 10 cm. line with descriptors at each end which has been shown to be valid and reliable for quantifying pain perception (Lee & Kieckhefer, 1989). The left descriptor indicated no pain/soreness and the right descriptor indicated extreme pain/soreness. Subjects were asked to place a vertical mark through the VAS, indicating the amount of muscle pain experienced in the biceps brachii. The vertical mark was measured to the nearest 0.1 cm from the no pain/soreness descriptor. The average of two separate measurements was utilized for data analysis.

Biceps brachii muscle shortening was assessed, to the nearest degree, via resting elbow joint angle secondary to edema with a universal 12 in. plastic goniometer. Subjects were instructed to stand with arms relaxed at the side in anatomical position. The data collector aligned the axis of the goniometer with the previously identified lateral epicondyle. The stationary arm was aligned with the acromion process and the movable arm was aligned with the radial styloid process with the forearm passively supinated,

using zero degrees as the starting position. The average of three measurements was used for data analysis.

Biceps brachii edema was assessed via circumference measurements with a Gulick anthropometric measuring tape. The tape measure is designed to provide consistent tension during data collection via a spring located at the end of this measuring tape. Four, eight, and 12 cm sites proximal to the medial and lateral epicondyles of the humerus were marked with permanent ink. The average of two measurements, to the nearest 0.1cm, at each site were used for data analysis. Circumference measurements were taken prior to punctuate pressure (muscle tenderness) measurements to avoid influence of additional edema formation.

Muscle tenderness was assessed with a modified Newham punctate technique with the Model 75 Force Gauge Probe (Technical Products Company, Caldwell, NJ). The punctate/pressure device consists of a blunt 2 mm probe attached to a force gauge designed to assess palpable tenderness. The maximum capacity of the force gauge is 14 lbs, marked in 4 oz increments until 16 oz, followed by one lb increments until 14 lbs. The force gauge probe was compared to weights established by the National Bureau of standards and reliability was reported as $r = .99$. A polyurethane template perforated at 10 sites, 3 medial and 3 lateral holes spanning the length of the two heads of the biceps brachii and 4 holes spanning the length of the mid biceps brachii muscle, was used to standardize punctate pressure application. A mid-biceps reference line was placed at the bottom of the polyurethane sheet. Subjects were positioned supine with the arm slightly abducted and the forearm completely supinated. A 30 degree wedge was placed under the forearm and pressed against the olecranon to allow the elbow flexor muscles to relax

at an angle that would remain consistent across subjects. The polyurethane template was positioned by aligning the reference line with a permanent marker dot located between the medial and lateral epicondyles at the midway point in the antecubital space. The probe was held perpendicular to the skin surface as it pierced the template at each of the 10 sites with gradually increasing force. Subjects were instructed to indicate when pressure turned to pain by saying "stop". Muscle tenderness pain data were taken only once per site. The sum of the 10 sites was used for data analysis.

The Biodex System 3 dynamometer was used to assess biceps brachii isometric force production and to induce DOMS. The isometric mode of this system has been proven to be valid and reliable (Drouin *et al.*, 2001). Drouin et al reported a coefficient of .99 for validity and Valovich et al (Drouin et al., 2001) reported a coefficient of .99 for reliability. To avoid any influence of the isometric force production on the other dependent variables, isometric data collection was performed last. Subjects were positioned according to the manufacturer's recommended settings. The testing angle was set at 60 degrees of elbow flexion. The recommended testing angle for isometric strength of the biceps muscles is elbow flexion slightly less than 90 degrees (Kendal *et al.*, 1992). Subjects performed three isometric contractions, each lasting five seconds with a 30 second rest period between repetitions. The average of three isometric contractions was used for data analysis.

Statistical Analysis

Our methodology involved bilateral DOMS inducement to provide subjects a control baseline and to standardize subjective treatment outcomes. Quantification of DOMS inducement was verified with seven separate, 2 x 5 ANOVAs with Repeated Measures.

In these analyses the sham treatment and control arms represented the between subjects variables and the five treatment days represented the within variables. After DOMS inducement was established and no placebo effect was revealed, only the randomly selected treatment arm data of days two through five (four days) were used for MENS treatment outcome analyses. Fourteen, 3 x 4 ANOVAs with Repeated Measure were used to assess cumulative and acute MENS treatment outcomes. Cumulative effects were assessed via the daily post-treatment test data, while acute effects were calculated as the difference (delta) between the daily pre-treatment test and the post-treatment test data. The independent variables were MENS treatment group, healing, pain, and sham. The dependent variables were: VAS, Punctate, Circumference (4, 8, and 12 cm), Resting Joint Angle, and Isometric Torque. All data were analyzed with the Statistical Analysis System (SAS Institute, Inc. Cary, NC) with the alpha level set at 0.05.

Results

Perceived pain, palpable tenderness, circumference four cm, 8 cm, 12 cm, resting joint angle (biceps shortening), and biceps isometric force means and standard deviations for post treatment, for days 2-5 are presented in Tables 1-7. Raw data for perceived pain, palpable tenderness, circumference four cm, 8 cm, 12 cm, resting joint angle (biceps shortening), and biceps isometric force are presented in Appendix.

Table 1Perceived Pain Means and Standard Deviations for Groups During the 5-Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	3.1 2.99	4.0 2.77	3.65 2.76	3.13 3.08	1.84 2.09
Pain	2.58 2.97	3.7 2.19	3.37 2.07	2.73 2.36	1.61 1.91
Sham	2.37 2.51	2.88 2.2	2.64 2.0	2.08 2.29	1.26 1.73
Group Mean	2.68 2.8	3.53 2.41	3.22 2.3	2.64 2.59	1.57 1.9

Table 2 Palpable Tenderness Means and Standard Deviations for Groups During the 5-Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	41.3 11.59	36.35 12.68	38.25 14	40.65 12.17	45.1 13.11
Pain	41.25 10.53	34.75 9.14	36.25 10.42	36.15 10.9	40.9 8.97
Sham	38.1 11.59	30.52 10.86	33.2 13.14	34.9 10.59	36.3 9.6
Group Mean	40.22 11.16	33.87 11.08	35.9 12.57	37.23 11.23	40.77 11.14

Table 3 Circumference 4 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	26.03 2.85	25.99 2.84	26 2.8	26.23 2.77	26.24 2.75
Pain	24.87 2.88	24.97 2.54	25.08 2.77	25.27 2.58	25.32 2.7
Sham	25 2.75	25.16 2.72	25.13 2.89	25.29 2.67	25.46 2.58
Group Mean	25.30 2.83	25.37 2.7	25.4 2.8	25.59 2.67	25.67 2.66

Table 4 Circumference 8 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	28.67 3.11	28.26 3.13	28.24 3.15	28.28 3.02	28.43 3.11
Pain	27.15 3.14	27.09 3.03	27.13 3.08	27.24 3.11	27.15 3.07
Sham	26.77 2.88	26.69 2.62	26.85 2.93	26.96 2.85	27.09 2.77
Group Mean	27.39 3.06	27.35 2.96	27.40 3.06	27.49 3.00	27.56 3.00

Table 5 Circumference 12 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	30.03 3.42	29.95 3.28	29.88 3.24	29.85 3.32	29.94 3.23
Pain	28.70 3.37	28.56 3.35	28.54 3.39	28.58 3.28	28.62 3.33
Sham	28.19 3.21	28.25 3.16	28.2 3.2	28.37 3.22	28.49 3.11
Group Mean	28.97 3.36	28.92 3.29	28.87 3.30	28.93 3.28	29.01 3.24

Table 6 Resting Joint Angle (Biceps Shortening) Means Standard Deviations for Groups During the 5 Day Treatment Period Post Treatment

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
Healing	30.55 7.92	30.6 8.43	29.15 7.34	29.05 6.84	26.45 5.67
Pain	27.50 9.01	27.70 6.36	27.55 5.30	27.35 6.35	26.95 4.99
Sham	30.50 9.31	29.55 6.73	29.30 7.05	29.30 7.65	27.90 7.13
Group Mean	29.51 8.74	29.28 7.21	28.66 6.56	28.56 6.90	27.1 5.93

Table 7 Biceps Isometric Force Means and Standard Deviations for Groups During 5-Day Treatment Period Post Treatment

Treatment	Day 1		Day 2		Day 3		Day 4		Day 5	
Healing	31.91	14.78	35.23	15.76	39.24	17.82	40.10	17.41	41.55	17.68
Pain	21.83	15.03	28.05	17.34	29.21	17.91	30.77	18.74	32.72	19.64
Sham	25.24	21.14	27.74	21.23	29.97	22.30	30.18	23.74	30.82	24.48
Group Mean	26.33	17.46	30.34	18.28	32.81	19.67	33.68	20.33	35.03	20.98

Table 8 Perceived Pain Means and Standard Deviations for Groups During the 5-Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	.09 ± .76	.40 ± 1.27	.21 ± .59	.30 ± .57
Pain	.02 ± 1.47	.23 ± .59	.07 ± .57	-.11 ± .623
Sham	-.00 ± .74	.45 ± .58	.15 ± .71	.09 ± .38
Group Mean	.03 ± 1.03	.36 ± .86	.14 ± .625	.09 ± .55

Table 9 Palpable Tenderness Means and Standard Deviations for Groups During the 5-Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	2.1 ± 5.56	.8 ± 6.41	-.03 ± 4.39	.45 ± 4.41
Pain	1.3 ± 4.53	1.45 ± 4.1	3.5 ± 4.92	.65 ± 3.75
Sham	2.69 ± 6.34	-.1 ± 4.86	-.3 ± 4.96	.95 ± 4.85
Group Mean				

Table 10 Circumference 4 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	-.01 ±. 39	.-12 ± .62	.02 ± .42	.46 ± .73
Pain	.0 9 ± .74	-.16 ± .38	-.08 ± .45	.44 ± .68
Sham	-.02 ± .3	-.0 9 ± .55	-.65 ± .30	.67 ±. 89
Group Mean	.01 ± .51	-.12 ± .52	-.04 ± .39	.52 ± .77

Table 11 Circumference 8 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	-.03 ± .31	.03 ± .41	.1 ± .31	-.1 ±.34
Pain	.1 ± .33	-.065 ± .29	-.16 ± .68	.03 ± .25
Sham	.19 ± .81	.01 ± .25	.09 ± .27	.04 ± .20
Group Mean	.08 ± .53	.00 ± .32	.01 ± .47	.00 ± .27

Table 12 Circumference 12 CM. Means and Standard Deviations for Groups During the 5-Day Treatment Period Post. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	.04 ± .34	.10 ± .67	.19 ± .77	-.06 ±
Pain	.12 ± .37	.00 ± .28	.11 ± .85	-.01 ± .35
Sham	.04 ± .28	.05 ± .35	.04 ± .27	-.04 ± .28
Group Mean	.07 ± .33	.05 ± .46	.11 ± .67	-.03 ± .42

Table 13 Resting Joint Angle (Biceps Shortening) Means Standard Deviations for Groups During the 5 Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	-.2 ± 2.48	1.1 ± 2.07	2.0 ± 3.75	2.4 ± 3.06
Pain	.65 ± 3.8	.7 ± 2.34	.6 ± 1.6	.15 ± 3.96
Sham	1.35 ± 1.98	1.25 ± 2.35	-.25 ± 2.98	1.55 ± 2.56
Group Mean				

Table 14 Biceps Isometric Force Means and Standard Deviations for Groups During 5-Day Treatment Period. Delta

Treatment	Day 2	Day 3	Day 4	Day 5
Healing	4.29 ± 4.0	3.32 ± 1.72	5.66 ± 7.49	4.29 ± 3.24
Pain	4.88 ± 4.31	2.65 ± 2.21	3.91 ± 2.87	3.88 ± 2.92
Sham	4.41 ± 3.77	3.96 ± 2.79	4.34 ± 4.6	4.45 ± 3.6
Group Mean	4.52 ± 3.92	3.33 ± 2.33	4.58 ± 5.09	4.2 ± 3.19

Cumulative (Post) Treatment for Days Two to Five

Significant group main effects for treatment arm cumulative (post-treatment) data for all seven dependent variables were not revealed. Similarly significant treatment group by day interactions were not revealed. Conversely, significant treatment day main effects were revealed for all seven of the following dependent variables.

Perceived pain (VAS) F values indicated a significant treatment day main effect ($F = 36.87$, $p < .00$) regardless of group. Results of the Newman-Keuls post-hoc test indicated significant decreases in perceived pain values between treatment day 2 and days 4, and 5 and between treatment day 3 and days 4 and 5; and between treatment days 4 and 5.

Resting joint angle (biceps brachii shortening) F values indicated a significant treatment day main effect ($F = 6.02$, $p < .05$) regardless of group. The Newman-Keuls post-hoc test indicated significant increases in resting joint angle between treatment days 2 and 5; 3 and 5; and 4 and 5.

Circumference (edema) F values four and eight cm proximal to the lateral epicondyle indicated significant treatment day main effects ($F = 8.08$, $p < .00$) regardless of group. The Newman-Keuls post-hoc test indicated significant increases in circumference values between treatment day 2 and days 4 and 5; and between day 3 and days 4 and 5.

Circumference (edema) F values 12 cm proximal to the lateral epicondyle indicated significant treatment day main effects ($F = 2.92$, $p < .05$) regardless of group.

The Newman-Keuls post-hoc test indicated significant increases in circumference (edema) values between treatment days 3 and 5.

Muscle tenderness pain F values indicated a significant treatment day main effect ($F = 19.70$, $p < .00$) regardless of group. The Newman-Keuls post-hoc test indicated significant increases in palpable tenderness pain values between treatment day 2 and days 3, 4, and 5; and between days 3 and 5; and days 4 and 5.

Biceps brachii isometric force F values indicated a significant treatment day main effect ($F = 7.71$, $p < .00$), regardless of group. Results of Newman-Keuls post-hoc test indicated a significant increase in biceps brachii isometric force values between treatment day 2 and days 3, 4, and 5, and between days 3 and 5.

Acute (Delta) Treatment for Days Two to Five

Significant group main effects for treatment arm acute (Delta) data for all seven dependent variables were not revealed. However, a significant treatment group by day interaction ($F = 2.36$, $p < .0327$) was revealed for treatment arm resting joint angle (biceps brachii shortening). The Greenhouse-Geisser Epsilon critical value (0.9315) indicated a significant increase in healing group elbow joint range of motion on treatment day four, when compared to the pain and sham groups. Significant increases in healing and sham group elbow joint range of motion was also revealed, on treatment day five when compared to pain group.

Treatment group by day interaction ($F = 3.07$, $p = 0.0543$) neared significance for treatment arm biceps brachii tenderness pain. The Greenhouse-Geisser Epsilon critical value (0.9222) indicated a significant decrease in the pain group muscle tenderness pain on treatment day four, when compared to the healing and sham groups.

No significant treatment day main effects were revealed for Perceived pain (VAS) and circumference (edema) eight and 12 cm proximal to the lateral epicondyle. Significant treatment day main effects were revealed for the following three dependent variables.

Circumference (edema) F values four cm proximal to the lateral epicondyle indicated significant treatment day main effects ($F = 14.09$, $p = .0001$) regardless of group. The Newman-Keuls post-hoc test indicated significant increases in circumference values between treatment days 2 and 5, 3 and 5, 4 and 5. Biceps brachii isometric force F values indicated a significant treatment day main effect ($F = 20, 43$, $p < .00$), regardless of group. Results of the Newman Keuls post-hoc test indicated a significant increase in biceps brachii isometric force values between treatment day 2 and days 3, 4, and 5, and between treatment day 4 and days 3 and 5.

Discussion

Controlled scientific research on MENS treatment of athletic injuries is limited to a few inconclusive studies involving the treatment of DOMS (Allen et al., 1999; Bonacci & Higbie, 1997; Denegar et al., 1992; Lambert et al., 2001; Weber et al., 1994). Experimental methodologies in these studies were inconsistent and treatment parameters appear to be anecdotal and unfounded or from the non-clinical trails of Wallace(not scientifically based)(Wallace, 1990). A review these studies revealed a common reference to Manley(Allen et al., 1999; Bonacci & Higbie, 1997; Denegar et al., 1992; Lambert et al., 2001; Weber et al., 1994) Picker (Bonacci & Higbie, 1997; Denegar et al., 1992; Weber et al., 1994). Conversely, MENS successful treatment of fracture and wounds is well documented, all of these studies incorporated timely use of negative polarity (Brighton et al., 1981; Carley & Wainapel, 1985; Connolly et al., 1997; DC Paterson et al., 1982; Mulder, 1991; Wolcott et al., 1969) Consequently, we utilized treatment parameters aligned with fracture and wound healing and delineated parameters that could be used to identify specific outcomes in an attempt provide a more scientific bases for these treatments. To that end we bilaterally induced DOMS so that treatment outcome data would not be misconstrued with successful MENS treatment and to quantify DOMS inducement.

The most significant findings in our study was that MENS negative polarity increased acute resting joint angle (decreased muscle shortening) of the Healing Group ($p < .0327$) only on the fourth treatment day and increased resting joint angle of the Healing and Sham Groups on the fifth treatment day. Our findings are supported by Lambert who also found a significant increase in elbow resting joint angle and was the only

investigator who utilized negative polarity for DOMS treatment and revealed significant treatment success. He also used a 8 cm x 15 cm patch that covered the majority of the biceps brachii for a countinuous 96 hour treatment. We also used negative polarity only, for a 40 minute on five consecutive days (3.333 hours total) and similarly revealed a significant increase in elbow joint range of motion.

Jahn (Jahn, 1968) states that calcium and phosphate are attracted to the cathode (-) and sodium and chloride ions migrate to the anode. Because calcium and is essential in osteoblastic activity it is essential that the cathode (-) be placed directly in the fracture site (Brighton et al., 1981; Connolly et al., 1997; Paterson *et al.*, 1982).

Additionally, negative polarity appears to have significantly ($p = .05$) decreased acute muscle tenderness pain in the Pain Group only on the fourth treatment day. These results are converse to all other MENS treatment studies. However, this finding is interesting in that our Pain Group parameter of 30Hz was selected secondary to the non-experimental MENS treatment protocol literature. The recommendations delineate 30Hz for pain and .3 Hz for healing. All of the previous MENS DOMS treatment studies, except Lambert, involved .3Hz, 30Hz, or a combination of the two protocols. Lambert used an electrostatic membrane that discharged a current of 20 μA over the whole 96 hour treatment period. Our study involved specifically separating the two protocols and doubling (40 minutes) typical treatment times utilized by athletic trainers (20 minutes) in order to substantiate the healing and pain descriptors. Perhaps combining the treatment protocols diluted the effects of these parameters.

Microcurrent DOMS treatment parameters have been based on Cheng (Cheng & al, 1982) stated that 50 μA is needed to stimulate protein synthesis and 100 μA promotes

amino acid transport. Additionally, ATPase activity has been reported in a range from 10-1000 μA (Cheng & al, 1982) Friendenberg (Friedenber *et al.*, 1971)stated that currents < 5μA do not produce osteogenesis, currents between 5-20 μA progressively increase bone formation and currents of 20 μA show celluar necrosis, not bone formation. Milliamprage used in our study and all other MENS DOMS treatment studies ranged from 30 μA to 200 μA (Allen et al., 1999; Bonacci & Higbie, 1997; Denegar et al., 1992; Weber et al., 1994)

Our cumulative treatment day main effects for all dependent variables revealed significant increases in pain and edema and decreases in resting joint angle (increased muscle shortening) and isometric peak torque between the first day of DOMS inducement and 24 to 48 hours post inducement. These findings are supported by all other MENS treatment of DOMS studies (Allen et al., 1999; Bonacci & Higbie, 1997; Denegar et al., 1992; Lambert et al., 2001; Weber et al., 1994)

Lastly, fractures and wound studies involved MENS treatment for weeks to months at a time (Bonacci & Higbie, 1997; Connolly et al., 1997; Paterson et al., 1982). Our study involved an intermittent 3.333 hour total treatment and Lambert (Lambert et al., 2001)and Bonacci (Bonacci & Higbie, 1997)utilized 96 and 40 hours of extended continuous treatment even then our successful treatment of DOMS was limited. Additionally, long MENS treatments are impractical for the treatment of DOMS since DOMS symptoms peak 24-48 hours post eccentric exercise and longer treatment for other soft tissue injuries needs to be investigated Perhaps MENS treatment protocols should be carefully delineated to injury tissue type.

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APPENDICES

Part II

Review of Literature

Microcurrent Treatment of Delayed Onset Muscle Soreness

Denegar et al (1992) investigated the effect Microcurrent (MENS) and placebo treatments had on Delayed onset muscle soreness. Subjects were 16 volunteers who were randomly assigned to MENS and static stretching (MSS) or placebo and static stretching (PSS) treatment groups. Delayed onset muscle soreness (DOMS) was induced to the non dominant elbow flexor muscle group. Initially each subject eccentrically lowered a 30-lb dumbbell from elbow flexion to extension in a three second time period. Subjects continued to perform eccentric muscle activity until they were unable to control lowering the weight due to muscle fatigue, at which time the resistance was decreased by 5 lbs. This process was continued until the subject could not control 5 lbs. or had completed 10 repetitions with 5 lbs. The investigators returned the arm to the flexed position for each repetition. Treatment was administered after induction of DOMS and at 24, 48, 72, 96, and 196 hours post DOMS administration. Microcurrent treatment was delivered with two round (50-mm diameter) self-adhering carbon-rubber electrodes. The electrodes were applied over the muscle belly of the biceps brachii and over the antecubital fossa of the involved arm and held in place with elastic wraps. Stimulation was generated with an Acutron Multiwave Stimulator. The stimulation parameters were 100 μA, .3 pps, and an alternating polarity for 20 min. The placebo treatment was administered in an identical manner except that the timer was turned off. Pain was assessed with a graphic pain rating scale. Immediately following treatment, each subject performed four 30 second static

stretches of the elbow flexor muscle group with 30 seconds rest period between stretchs Elbow extension range of motion was measured with a standard long-arm goniometer while subjects were positioned supine with the arm adducted and the forearm supinated. Strength was assessed via a Kin-Com Isokinetic Dynamometer. Average concentric torque was measured from 90 degrees to 135 degrees flexion at an angular velocity of 30 degrees/sec. A univariate, one between (treatment group) and one within subjects (measurement time) factors analysis of variance (ANOVA) was conducted on change in ROM, pain, and average torque. No significant differences were found between MENS and placebo treatments on any of the variables, but the MENS treatment did provide a transient analgesic effect 24 and 48 hours following the eccentric exercise.

Weber (1994) investigated the effects of massage, MENS and upper body ergometry on DOMS symptoms of 40 healthy, untrained female volunteers between the ages of 18 and 35. Subjects were randomly assigned to one of 4 groups: massage, MENS, upper body ergometry, or control. DOMS was administered to the non-dominant biceps muscle group via an Eagle arm-curl weight machine eccentrically. The one-repetition max (1RM) load, plus one plate was used as the starting resistance. Subjects eccentrically lowered the weight for a five second count for 10 repetitions, with the elbow passively returned by the principal investigator to the flexed position and a one minute rest period provided between sets. The same routine was repeated until ten repetitions could not be completed, at which time the weight was continually reduced by one-half of a plate until fatigue. Treatment was applied immediately following DOMS administration and 24 hours post eccentric activity. Data were collected immediately post eccentric activity and at 24 and 48 hours post DOMS administration. Massage treatment involved light effleurage for two minutes, petrissage for five minutes, followed

by effleurage for one minute with the arm slightly elevated. Upper body ergometry treatment was administered via an Eagle upper body ergometer at 60 rpm at a workload of 400 kg m/min. in a counter clock wise direction. Microcurrent treatment was administered at 30μA, .3Hz, a wave slope of .5 seconds, 50% duty cycle, with alternating polarity every 2.5 seconds for eight minutes. Treatment was applied using two, 4.57 x 4.57 cm self adhesive electrodes with one pad place over the bicipital insertion and the other over the long head of the biceps brachii. Perceived pain data were collected via a visual analogue scale to assess muscle soreness. The Cybex 2 isokinetic dynamometer was used to collect isometric and isokinetic data. Isometric force production involved three five second contractions at zero degrees per second with the elbow flexed to 90 degrees and a one minute rest period provided between each set. Isometric peak force production data of the three contractions were used for data analyses. Isokinetic peak torque data were collected at 60 degrees per second using three consecutive maximum effort repetitions. Isometric peak force and isokinetic peak torque data were analyzed using split-plot 4 x 3 analyses of variance (ANOVA). Interaction and treatment effects were determined using Kruskal-Wallis tests and time effects were determined using a Wilcoxon signed rank test. Results indicated that soreness was greater at 48 hours post eccentric activity than at 24 hours post eccentric activity, indicating that the protocol used to induce DOMS was effective. No significant differences were found between treatment groups for perceived pain, isometric peak force, and isokinetic peak torque at 0, 24, or 48 hours. The results of this study indicated that MENS was not effective in reducing the symptoms of DOMS.

Bonnaci and Higbie (1997) used a double-blind research design to investigate the effect (LVMAS) had on perceived pain and muscle strength following eccentric exercise.

Eighteen subjects; 12 females and 6 males were randomly assigned to experimental (EXP), control (CON), or sham (SHAM) groups. DOMS was administered to the non-dominant elbow flexor muscle group via an exercise machine designed for eccentric exercise. Subjects lowered a weight over three second time period that was 90% of their 1RM until lack of control was evident. The elbow was then passively returned to the flexed position by the investigator. Resistance was decreased in decrements of 2.25kg until 10 repetitions were completed or subjects could no longer control the weight. Treatment was administered immediately following eccentric activity and at 24, 48, 72, and 96 hours post eccentric activity. Prior to treatment EXP and SHAM groups attended a mandatory orientation session to learn and practice applying electrodes of the M.E.N.S. 2000ST unit over the biceps brachii muscle and adjusting the settings. The sham and experimental groups received 20 min. of treatment during the day at 100μA, 0.3Hz, with biphasic polarity and were also instructed to treat the involved arm for at least 8 continuous hours overnight using the same settings. Muscle strength was measured using a 1RM eccentric isotonic test to assess muscle function. Perceived pain data were assessed using a graphic pain-rating scale to determine muscle soreness. Perceived pain and muscle strength data and perceived pain deltas of the EXP and SHAM groups, were analyzed using ANOVA'S with repeated measures. A post hoc power analysis was used to interpret nonsignificant group by time interactions reported in all ANOVAs. Results indicated a significant decrease in 1RM eccentric torque at 24 ($F(2,75) = 14.24$, $p=034$) and 48 ($F(2,75)= 10.33$, $P= .0468$) hours for all groups. Results also indicated that all groups returned to baseline levels within 72 hours following the administration of DOMS. No significant differences in 1RM eccentric torque ($F(8,75)=0.07$, $p=.9997$) and graphic pain-rating scale scores ($F(8,75)=0.30$, $p=.9636$ were found among the three

groups. The results of this study indicated that MENS did not reduce pain or expedite return of eccentric strength levels following DOMS administration.

Allen (1999) used a double-blind research design to examine the effect MENS had on pain and loss of range of motion (ROM) associated with DOMS. Eighteen male (3) and female (15) subjects were randomly assigned to MENS treatment or MENS sham groups. Delayed onset muscle soreness was administered to the biceps brachii muscle via dumbbells. Male subjects began eccentric activity with a 13.5 kg (30 lb.) load and females used a 11.25 kg (25 lb.) load. Subjects eccentrically lowered the weight to a three second count, while the principal investigator passively returned the elbow to the flexed position, until the weight could no longer be controlled during the three second lowering period. Resistance was decreased in 2.25 kg decrements until a weight of 2.25 kg was reached at which time subjects performed repetitions to fatigue or until 10 repetitions were attained. Twenty minute MENS treatments, 10 minutes at 200μA and 30 Hz and 10 minutes at 100μA and .3 Hz, were administrated 24, 48, and 72 hours post eccentric activity. The MENS treatment was applied with a 5.08 x 10.16 cm. (2 x 4 inch.) positive electrode over the belly of the biceps brachii. An electrode of the same size was placed over the belly of the triceps brachii.

Dependent variables were elbow range of motion (ROM) assessed via a standard plastic goniometer. Muscle pain assessed via a graphic rating scale (GRS) as constant pressure was applied to the belly of the biceps brachii muscle while subjects actively extended the elbow. Constant pressure assessed via á 2.25 kg ankle weight attached to a orthoplast sphere while subjects were seated with the arm resting at 90 degrees of shoulder abduction and 90 degrees of elbow flexion. Three repeated measures

ANOVAs were used to analyze pain and range of motion data. The between subjects and within subjects variables were group, test day, respectively. A significant day-by-test interaction was found for GRS extension ($F(3, 48)=5.04$, $p= .402$), and ROM ($F(3,48)= 19.77$, $p= .001$) data. No significant differences were found for any of the group-by-test interactions: GRS-Orthoplast sphere ($F(1,16)=0.74$, $p=3.42$). The results from this study indicated that MENS treatment was not effective in reducing pain and loss of ROM associated with DOMS.

Lambert (2002) conducted a double-blind, placebo controlled study to investigate the effectiveness of Acustat microcurrent on pain, inflammation, and loss of function associated with DOMS. Subjects were 30 male volunteers who were assigned to either an experimental group (Acustat) or a placebo group (Placebo Acustat). Eccentric muscle activity was administered to the subject's non-dominant elbow flexor muscle. While the dominant arm served as the control. The Kin-Com isokinetic dynamometer was used to administer DOMS by eccentrically lowering the elbow through 5 sets of 25 repetitions at 80% of a 1RM. Placebo and active Acusat membranes were applied immediately after the eccentric exercise protocol for a 48 hour treatment, a new Acusat membrane was applied for a second 48 hour treatment period for a total treatment time of 96 continuous hours. Both arms were intermittently studied up to 168 hours post eccentric activity. Muscle soreness pain was assessed by pressing a costumed designed, round ended probe into the muscle. Muscle soreness pain was based on the probe penetration depth (0 cm=score 4, 1 cm=score of 3, 2 cm=score of 2, 3 cm=score 1, and 4 cm=score of 0). Muscle soreness pain was also measured subjectively using a "rating of general perceived pain based on a scale of 1-10. Edema was assessed via a girth measurement taken midway between the acromion and the head of the radius. Biceps muscle shortening was

assessed via resting joint angle measured with a goniometer. Isokinetic torque data were collected with the Kin-Com isokinetic dynamometer via a 1 RM at 60 degrees per second. Creatine kinase

(CK) activity was assessed via blood samples collected from the antecubital vein and analyzed using spectrophotometric enzymatic assays to assess creatine kinase (CK) activity. ANOVA's with repeated measures were used to analyze the data. Results indicated significant increases in perceived pain ($F=58.02$; $P<0.0000001$), muscle soreness pain ($F=79.2$, $P<0.0000001$), and edema (girth)($F=17.75$, $P<0.0000001$) over time regardless of group. Edema results indicated significant increases in girth of the exercised arms from 12 hours post eccentric activity until 120 hours later. Biceps muscle shortening (resting joint angle)($F=2.063$; $P<0.05$), isokinetic torque ($F=6.3$; $P<0.01$), and CK activity ($F=3.0$; $P<0.01$) analyses indicated significant group by time interactions. Biceps muscle shortening results indicated that resting joint angle of the exercised arms of the placebo Acustat group produced significantly lower torque data 12 and 24 hours post eccentric activity than the active Acustat group. Creatine kinase activity of the active Acustat group was significantly lower at 96, 120, 144, and 168 hours than the placebo Acustat group. The results from this study indicated that Acustat treatment reduced some of the symptoms of DOMS as biceps muscle length and isokinetic torque data were maintained, and CK activity was reduced.

Literature on low intensity stimulator treatment for DOMS provides uncertainty about the effectiveness of the modality to treat the symptoms of DOMS. MENS treatment has not effectively reduced muscle pain and edema ( ) however, resting joint angle (muscle restriction) improved with MENS application in one study ( ). The successful treatment of DOMS symptoms noted in the Lambert et al study may be

attributed to treatment protocol relative to electrode size and polarity of MENS treatment parameters. Lambert et al used a 8 cm x 15 cm electro-membrane with negative polarity that covered a larger surface treatment area than Weber et al, Bonacci and Higbie, and Allen et al who utilized 4.57 cm. x 4.57 cm, 177mm. diameter, and 5.08 cm. x 10.16 cm. electrodes, alternating or positive polarity, respectively. Lambert et al also utilized an electro-membrane to deliver MENS treatment for 96 continuous hours, while Weber et al, Bonacci and Higbie, and Allen et al applied MENS treatments via standard MENS application periods ranging from eight to 20 minutes. Current literature fails to provide conclusive evidence that MENS is an effective treatment for DOMS symptoms.

Microcurrent Treatment of Wounds

Mulder (1991) conducted a double blind, multi-center study to investigate the healing effect of electric stimulation and sham stimulation on open-skin wounds. Fifty wounds were included in this study, 26 wounds were treated with electrical stimulation and 24 wounds were treated with sham stimulation. A portable stimulation unit with three intensity levels; 30, 35, 40 μA, and a pulse width of 140 μsec, a charge per pulse of 4.2, 4.9 and 5.6 microcoulombs was used to provide treatments. Frequencies of 64 and 128 pulses per second were selected and negative polarity was used until the wounds were clean and free of necrotic tissue, or until serosanguinous drainage appeared. Wounds not infected at the start of the study were treated for three days with negative polarity, and then positive polarity was applied. Wounds were treated twice a day for 30 minutes with electric or sham stimulation. The second daily treatment was given between four and eight hours after the first treatment. Wounds in the treatment group showed a 56 percent decrease in initial size compared to 33 percent decrease for wounds in the control group. The author concluded that electrical stimulation might induce an

increase in tensile strength and re-epitheliztion and a decrease in bacterial burden, thereby contributing to rapid wound closure.

Wood et al (1993) used a double blind placebo design to study pulsed low intensity direct current (PLIDC) for the treatment of stage II and III decubitus ulcers. Pulsed low intensity direct current was used to deliver a .8 Hz, 600 μA of pulsed treatment with negative polarity.. The electrodes were placed on opposite sides of the wounds approximately two cm. from the margins. Treatment included three applications around each ulcer on alternate days. The sham group received treatment through an identical PLIDC instrument, but the current was impeded on this instrument. Both treatment and control groups were randomly assigned and there were no significant differences in age, ulcer chronicity, and resistance to prior treatments, or degree of physical inactivity between these randomly selected groups. Ulcers in both groups did not respond to conventional treatment. Fiftyeight percent of ulcers in the control group healed completely in eight weeks compared to three percent in the placebo group. The authors concluded that PLIDC significantly increased healing in treated ulcers due to increased ATP and protein synthesis. They also stated that PLIDC may trigger many other biochemical and biophysical processes in the skin including calcium homeostasis, and growth factor binding.

Wolcott (1969) conducted a study to investigate the effect electrotherapy had on ischemic skin ulcers. Subjects were 67 patients with a total of 83 ischemic skin ulcers, 75 percent of these ulcers had already received standard treatment with no positive results. Prior to the study treatment all ulcers underwent standard debridement and cleaning. Initially the negative electrode was sandwiched between six gauze pads under the electrodes and two gauze pads over the electrodes. The positive electrode was

sandwiched between four pads to the skin 15-cm. proximal to the lesion. Both electrodes were then saturated with ringer's solution. Current was set at 600 micro Amps. After two hours of treatment the current to the negative electrode eliminated and the ulcer was evaluated. If drainage of the ulcer was copious and serous without evident bleeding the current was increased to 800μA. If the gauze was bloody the current was reduced to 400μA. Treatment cycles, for three days, involved two hours on and four hours off for a total of six hours in a 24 hours period, after which the electrodes were switched. Each day before application of the positive electrode the wound was inspected for pink granulation tissue forming at the base and for marginal re-epithelializtion. If growth was not evident the polarity of the electrodes was reversed and each day growth was monitored until the second growth phase plateau. There after the electrodes were altered every 24 hours until the ischemic lesion was completely healed. Forty percent of previously treated ulcers completely healed. The remainder of the ulcers revealed a healing rate that ranged from zero to 97 percent. The author concluded that proper applications of LIDC are clearly beneficial in the treatment of ischemic skin ulcers.

Microcurrent treatment of Fractures

Brighton et al. (1981) investigated the use of implantable direct current (DC) in the treatment of non-unions at the University of Pennsylvania. Seven years later the study was expended to include 12 participating investigators throughout the United States.

The University of Pennsylvania study included 186 patients who had 189 non-unions that averaged 2.7 years from the time of fracture. Power packs delivering a constant DC of 20μA were used. One to four stainless-steel wire cathodes, 1.2 mm in diameter and insulated with Teflon were inserted into the non-union without letting the bare tip of the cathode touch the metal. The anode was usually placed proximal to the

cast. The current was applied continuously for nine to 12-weeks. Lastly during the entire electrical treatment the involved extremity was immobilized in a plaster cast. After 12 weeks of electrical stimulation the cast and electrodes were removed and a weight-bearing cast without electricity was required for varying amounts of time for complete bone union to occur. Seventy-eight percent of the 189 non-unions treated with constant DC achieved solid bone union after the treatment protocol. Seventy-two percent of 80 non-unions treated at the University of Pennsylvania, that were treated with the identical protocol, achieved solid bone union.

Patterson (1982) conducted a multi-center study to investigate the effects of direct current bone growth stimulation (DCBGS) on bone healing. Subjects were 84 patients aged five to 81, 47 subjects had delayed-unions and 37 had nonunion fractures. Two surgical techniques were used by orthopedic surgeons. In the majority of cases the titanium cathode was placed across the fracture site coiled in the form of a helix and the platinum anode was positioned in the soft tissue at least 5 cm. from the cathode. In the second technique the cathode was threaded across the fracture site through small drill holes to from a figure eight. The DCBGS delivered 20μA over the range of 0-100,000 ohms and was either left in place for three months or in later cases six months. Clinical and radiological fracture healing was achieved in 72 of 84 patients (86 percent).

APPENDIX A

Health History Questionnaires

MEDICAL HISTORY FORM

Name_____ Date of Birth_____
SS# _____

Permanent Address _____
(off season) _____

Home Phone _____ Cell Phone _____
Host Family Name _____ Phone _____
Host Family Address _____
_____

Emergency Contact Person

Name _____ Relationship _____
Home Phone _____ Work Phone _____

Personal Insurance Carrier _____
Claim/Policy Number _____
Contact Phone Number _____
Please identify any condition you have had by indicating: *date, side/part of body, cause of injury, type of injury.*

Circle One

A: General Conditions
1. Fainting Spells _____
2. Headaches_____
3. Convulsions/epilepsy_____
4. Asthma_____
5. High Blood Pressure_____
6. Kidney Problems_____
Intestinal Disorders_____
Hernia_____
Diabetes_____
Heart Disorder_____
Poor Vision_____
Poor Hearing_____
Skin Disorder_____
Allergies (be specific)_____
Joint Dislocations_____

Bleeding Problems_____
17. Other _____
_____
_____

Injuries
1. Feet _____
2. Ankles _____
3. Lower Legs _____
4. Knees _____
5. Thighs _____
6. Hips _____
7. Lower Back _____
8. Upper Back _____
9. Ribs _____
10. Abdomen _____
11. Chest _____

12. Neck _____
13. Hands _____
14. Wrists _____
15. Forearms _____
16. Elbows _____
17. Upper Arms _____
18. Shoulders _____
19. Head _____

Date of last tetanus booster _____

Are you currently taking any medications? **Yes** **No**

If yes, describe medication, amount, and reason for taking:

_____
_____

Do you have any adverse reactions to anything (medications, food, animals etc)? **Yes** **No**

If yes, to what, and what are the reactions?

_____
_____

Do you wear glasses/contacts? **Yes** **No**

If yes, what is your prescription _____

Are you currently under a physician's care for any reason? **Yes** No

If yes, for what reason?

_____
_____
_____

I certify, to the best of my knowledge, everything I have stated on this form is true and correct.

_____ _____
Name (print) Signature Date

CODE NUMBER:_____.

Microcurrent Upper Extremity Questionnaire

PLEASE ANSWER THE FOLLOWING QUESTIONS TO THE BEST OF YOUR ABILITY

1. Have you injured either elbow in the last 12 months?

   NO_____ YES_____

2. Have you injured either elbow in the last 12 months?

   NO_____ YES_____

3. Have you injured either hand in the 12 months?

   NO_____ YES_____

4. Do you have a history of adverse reaction to eccentric (lengthening muscle contraction) exercise?

   NO_____ YES_____

5. Do you have any predisposing cardiorespiratory or cardiovascular or cardiovascular conditions that the researcher should be aware of?

   NO_____ YES_____

6. Do you have any other medical problems that the researcher should be aware of?

   NO_____ YES_____(If so, explain)

7. Have you ever undergone any type of surgery?

   NO_____ YES_____

If there are any questions, please feel free to contact us at the following number and address:

Toby Wolff, BS, ATC
University of Hawaii-Department of Kinesiology and Leisure Science
1337 Lower Campus Road, PE/A Complex, Room 231
Honolulu, Hawaii 96822
Phone #: (808) 221-5356

APPENDIX B

Committee on Human Studies Approval
Letter and Agreement to Participate In Form

UNIVERSITY OF HAWAI'I

Committee on Human Studies

MEMORANDUM

March 18, 2004

TO: Toby Wolff
Principal Investigator
Kinesiology and Leisure Science

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #12894- "Effects of Microcurrent Electrical Neuromuscular Stimulation on Delayed Onset Muscle Soreness"

Your project identified above was reviewed by the Chair of the Committee on Human Studies through Expedited Review procedures. The project qualifies for expedited review by CFR 46.110 and 21 CFR 56.110, Category (4) of the DHHS list of expedited review categories.

This project was approved on March 15, 2004 for one year. If in the active development of your project you intend to change the involvement of humans from plans indicated in the materials presented for review, prior approval must be received from the CHS before proceeding. If unanticipated problems arise involving the risks to subjects or others, report must be made promptly to the CHS, either to its Chairperson or to this office. This is required in order that (1) updating of protective measures for humans involved may be accomplished, and (2) prompt report to DHHS and FDA may be made by the University if required.

In accordance with the University policy, you are expected to maintain, as an essential part of your project records, all records pertaining to the involvement of humans in this project, including any summaries of information conveyed, data, complaints, correspondence, and any executed forms. These records must be retained for at least three years from the expiration/termination date of this study.

The CHS approval period for this project will expire on March 15, 2005. If your project continues beyond this date, you must submit a continuation application to the CHS at least four weeks prior to the expiration of this study.

We wish you success in this endeavor and are ready to assist you and your project personnel at any time.

Enclosed is your certification for this project.

Enclosure

2540 Maile Way, Spalding 252, Honolulu, Hawai'i 96822-2303
Telephone: (808) 539-3955/(808) 956-5007, Facsimile: (808) 539-3954, Web site: www.hawaii.edu/irb

UNIVERSITY OF HAWAI'I
Committee on Human Studies

MEMORANDUM

September 21, 2004

TO: Toby Wolff, ATC
Principal Investigator
Kinesiology and Leisure Science

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #12894 – "Effects of Microcurrent Electrical Neuromuscular Stimulation on Delayed Onset Muscle Soreness"

The proposed revisions to the protocol and consent form, for the project identified above, as explained in your status report form dated September 15, 2004, were reviewed by the Chair of the Committee on Human Studies through Expedited Review procedures. The proposed changes qualify for expedited review by CFR 46.110 AND 21 CFR 56.110, Category (b) of the DHHS list of expedited review categories.

These revisions were approved on September 20, 2004, for the current approval period. Please ensure that these revisions replace the previous version approved by the Committee. Should future revisions be considered, please contact this office for guidance as to whether Committee approval is required.

Thank you for your cooperation, and please do not hesitate to contact this office at 539-3955 if you have any questions or require assistance.

2540 Maile Way, Spalding 252, Honolulu, Hawai'i 96822-2303
Telephone: (808) 539-3955/(808) 956-5007, Facsimile: (808) 539-3954, Web site: www.hawaii.edu/irb

UNIVERSITY OF HAWAI'I

Committee on Human Studies

MEMORANDUM

February 17, 2005

TO: Toby Wolff
Principal Investigator
Kinesiology & Leisure Science

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #12894- "Effects of Microcurrent Electrical Neuromuscular Stimulation on Delayed Onset Muscle Soreness"

Your project identified above was reviewed by the Chair of the Committee on Human Studies through Expedited Review procedures. The project qualifies for expedited review by CFR 46.110 and 21 CFR 56.110, Category (8b) of the DHHS list of expedited review categories.

This project was approved on February 16, 2005 for one year. If in the active development of your project you intend to change the involvement of humans from plans indicated in the materials presented for review, prior approval must be received from the CHS before proceeding. If unanticipated problems arise involving the risks to subjects or others, report must be made promptly to the CHS, either to its Chairperson or to this office. This is required in order that (1) updating of protective measures for humans involved may be accomplished, and (2) prompt report to DHHS and FDA may be made by the University if required.

In accordance with the University policy, you are expected to maintain, as an essential part of your project records, all records pertaining to the involvement of humans in this project, including any summaries of information conveyed, data, complaints, correspondence, and any executed forms. These records must be retained for at least three years from the expiration/termination date of this study.

The CHS approval period for this project will expire on February 16, 2006. If your project continues beyond this date, you must submit a continuation application to the CHS at least four weeks prior to the expiration of this study.

We wish you success in this endeavor and are ready to assist you and your project personnel at any time.

Enclosed is your certification for this project.

Enclosure

2540 Maile Way, Spalding 252, Honolulu, Hawai'i 96822-2303
Telephone: (808) 539-3955/(808) 956-5007, Facsimile: (808) 539-3954, Web site: www.hawaii.edu/irb

UNIVERSITY OF HAWAI'I
Committee on Human Studies

MEMORANDUM

May 24, 2005

TO: Toby Wolff
Principal Investigator
Kinesiology and Leisure Science

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #12894-"Effects of Microcurrent Electrical Neuromuscular Stimulation on Delayed Onset Muscle Soreness"

This acknowledges receipt of your response dated May 18, 2005, to recommendations made by the Committee on Human Studies during its review of this project at its meeting of May 17, 2005. This information satisfactorily address the CHS concerns.

The proposed revision to the consent form were reviewed and approved by the Committee on Human Studies at its meeting on May 17, 2005.

These revisions were approved for the current approval period. Please ensure that this version replaces the previous materials approved by the Committee. Should future revisions be considered, please contact his office for guidance as to whether Committee approval is required.

Thank you for your cooperation, and please do not hesitate to contact this office at 539-3955 if you have any questions or require assistance.

2540 Maile Way, Spalding 252, Honolulu, Hawai'i 96822-2303
Telephone: (808) 539-3955/(808) 956-5007, Facsimile: (808) 539-3954, Web site: www.hawaii.edu/irb

AGREEMENT TO PARTICIPATE IN

Effects of Microcurrent Electrical Neuromuscular Stimulation
On Delayed Onset Muscle Soreness

Toby Wolff, BS, ATC
University of Hawaii
College of Education
Department of Kinesiology and Leisure Science
1337 Lower Campus Road, PE/A Complex, Room 231
Honolulu, Hawaii 96822

Phone #: 221-5356

1) Description

This study is part of a Masters Degree thesis by a University of Hawaii graduate student. The purpose of this research study is to determine the effectiveness of Microcurrent Electrical Neuromuscular Stimulation (MENS) on Delayed Onset Muscle Soreness (DOMS) and tissue healing in Elbow Flexor muscle. DOMS is the term used to describe the pain and stiffness, which is secondary to tissue damage, that is felt 1-2 days following strenuous physically activity or eccentric exercise (Gulick and Kimura, 1996). MENS is thought to possibly reduce pain and facilitate tissue healing. A routine Medical History form and a Microcurrent Upper Extremity Questionnaire, which will involve 5 minutes of your time, will be given to you prior to participation in the protocol. The medical questionnaire will be evaluated by Andrew Nichols, MD or Michelle LaBotz, MD (UH Team Physicians, Associate and Assistant Professors, respectively, of the John Burns School of Medicine, and UH Health Services Physicians) to determine your eligibility to participate in the study.

2) Procedures

You will be asked to perform 15 sets of 15 repetitions of negative biceps curls on both arms via a Biodex exercise machine. The Biodex exercise machine will produce a force that you will be asked to resist while your elbows straightens. One arm will receive one of 3 possible MENS treatments. The other arm will be used as the "control" The following measurements will be taken before elbow exercise and after each MENS treatment, on 5 consecutive days. The following measurements will be taken before elbow exercise and after each MENS treatment, for 5 consecutive days. Pain of the elbow flexors will be measured via a visual analogue scale (VAS) and the Model 75 force gauge probe. The VAS consists of a 10-cm. line with descriptors at each end. The left

end descriptor is no pain at all and the right end descriptor is unbearable pain. Each subject will place an "X" on the VAS to represent his/her level of pain. The Model 75 force gauge probe will be applied at 10 various sites along the elbow flexors muscles. When the pressure of the probe becomes painful, the amount of force will be measured and recorded. Range of motion, swelling and strength will also be determined using a goniometer, Gulick tape measure and Biodex isokinetic machine.

3) Confidentiality

The entire protocol will be held confidential. The researchers and you will be the only persons present in the laboratory while the test is being administered, and you name or identity will not be shown or indicated on any report of these data. All data and subject (identity) information will be kept under lock and key in the Department of Kinesiology and Leisure Science Research Laboratory. These materials will be permanently disposed of in a period not longer than 5 years. **This exercise is strictly voluntary and you may withdraw at any time without prejudice.**

4) Benefits

You may not receive any direct benefits from this study except gaining experience of being part of a scientific experiment. Participation in this study may provide a greater understanding of MENS as a treatment for DOMS. Positive treatment results may expedite the return to physical activity.

5) Risks

Due to the level of physical activity involved, the risk of injury such as muscle strain, **and, although very remote, possibly a cardiac event and rhabdomyolysis exists. Rhabdomyolysis is the breakdown of muscle fibers resulting in the release of muscle fiber contents into the circulation. Some of these are toxic to the kidney and frequently result in kidney damage.** In the event of any physical injury from the research procedure, only immediate and essential medical treatment is available. First Aid/CPR and a referral to a medical emergency room will be provided. The Principal Investigator is First Aid/CPR certified, and National Athletic Trainers' Association (NATA) certified athletic trainer. You should understand that if you are injured in the course of this research procedure that you alone may be responsible for the costs of treating your injuries.

Certification

I certify that I have read and that I understand the foregoing, that I have been given satisfactory answers to my inquiries concerning project procedures and other matters and that I have been advised that I am free to with draw my consent and to discontinue participation in the project or activity at any time without prejudice.

I understand that if I am injured in the course of this research procedure, I alone may be responsible for the costs of treating my injuries.

I herewith give my consent to participate in this project with the understanding that such consent does not waive any of my legal rights, nor does it release the principle investigator or the institution or any employee or agent thereof from the liability for negligence.

Signature of Participant:_____ date:_____

Signature of Investigator:_____ date:_____

If you cannot obtain satisfactory answers to your questions or have comments or complaints about your treatment in this study, contact: Committee on Human Studies, University of Hawaii, 2540 Maile Way Honolulu Hawaii 96822

Phone: (808) 956-5007

APPENDIX C

APPENDIX C

Raw Data for Perceived Pain, Palpable Tenderness, Circumference 4, 8, and 12 cm, Resting Joint Angle (Biceps Shortening), and Biceps Isometric Force for Post treatment and Delta Data

Appendix C-1. Raw Data for Circumference 4 cm. Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6	2	1	26.8	27	27	28	28.3
7	2	1	26	26	25.7	25.8	26
8	2	1	28	27.2	28.3	28	28.5
12	1	1	27.8	27.7	28	27.3	28
13	1	1	29.5	29.7	29.5	29.8	29.5
16	1	1	21	21.2	21	21	21
17	1	1	25.3	25.3	25.3	25.5	25.3
18	1	1	26.5	26	25.5	25.7	25.5
19	2	1	27.5	27.8	27.3	27.7	27.5
22	1	1	20	20	20.2	20.5	20.5
23	2	1	25.5	25.3	24.8	24.8	25
25	1	1	27.2	28.2	28	28.2	28.3
30	2	1	23.5	23.5	23.5	23.5	23.3
33	1	1	32.2	32	31.8	32.3	32
39	2	1	26.8	26.7	26.5	27	26.2
43	2	1	28.6	28.5	28.7	28.5	28.4
47	2	1	25.2	24.8	24.7	24.8	25.4
52	1	1	25.7	25.7	25.7	26	25.9
53	2	1	25.3	25.1	25.7	25.9	25.8
60	1	1	22.1	22.1	22.7	24.2	24.3
3	2	2	25.5	26	25.3	26.3	27
4	2	2	26	25.5	26.2	26.3	26
5	1	2	24.8	25	25.2	25.2	25.2
10	1	2	27.5	27.1	27.5	27.2	27.2
26	1	2	23.3	23.7	23.5	23.8	23.5
31	2	2	23.5	23.5	23	24	23.8
35	2	2	21	21.7	21.5	21.5	21.5
36	2	2	28	28	28.2	28	28
37	2	2	24.3	24.5	24.7	24.5	24.5
40	1	2	24.3	24	24.5	25	25
41	1	2	26	26.2	25.5	25.5	25.5
42	1	2	27.8	28	28.2	27.5	27.5
44	2	2	24.7	25.3	25.8	26.1	26.9
45	2	2	21.9	21.6	21.5	21.6	21.1
46	2	2	23.3	23.4	23.3	23.5	23.3
48	1	2	20.7	21.5	21	20.9	21.2
49	2	2	23.3	24	24.1	25.1	25.8
50	1	2	22.1	22.6	22.9	23.5	23.6
54	2	2	26.1	25.9	27	28.2	27.3
59	1	2	33.2	31.9	32.6	31.7	32.4
1	1	3	23.5	22.8	22.3	23.2	23.3
2	1	3	23.8	24.2	24	24	24
9	1	3	25	25	24.7	24.7	25
11	1	3	26	25.7	26.2	25.3	25.5

'14	2	3	30	29.8	30.2	30	30
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
15	1	3	24	24	23.7	23.5	24
20	2	3	21.5	22.2	21.7	21.5	22
21	1	3	24.5	24.5	24.7	26	26
24	1	3	21.3	21.5	21	21.5	21.3
27	2	3	26.5	26.2	26.5	26.2	26.2
28	1	3	21.3	22	22.5	24	24
29	2	3	25.8	26	26	25.7	26
32	2	3	21.6	22.1	22	23	23.5
34	2	3	27	27	27	27.3	27.2
38	1	3	22.5	22.5	22.5	22.3	22.8
51	2	3	29.2	29.4	29.5	29.8	29.5
55	2	3	23.3	23.7	23.8	24.1	24.6
56	2	3	26.8	27	26.6	26.8	26.9
57	2	3	26.6	27	26.5	26.1	26.4
58	2	3	29.7	30.6	31.2	30.7	31

Appendix C-2. Raw Data for Circumference 8 cm. Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
1	1	3	25.2	24.3	24	24.5	24.5
2	1	3	25.5	25.5	25	25.8	25.5
5	1	2	27	27	27.3	27.3	27.2
9	1	3	26.5	26.5	26.3	26.3	26.2
10	1	2	29.8	29.4	30.6	29.5	29.5
11	1	3	27.2	27.2	27.2	26.8	27
12	1	1	30.3	30	30.2	30.2	30.2
13	1	1	32	32.5	32	32	33.2
15	1	3	25.5	26	25.8	25.5	25.8
16	1	1	23	23	23	23.2	23
17	1	1	27.5	27.5	27.3	27.3	27.5
18	1	1	28.5	28	27.7	27.7	27.5
21	1	3	25.5	25.5	25.7	26.5	27
22	1	1	22	22.2	22.3	22.3	22.3
24	1	3	24.5	23.8	24.2	24	24.2
25	1	1	30	30.5	30.3	30.8	31.3
26	1	2	25.3	25.2	25	25	25
28	1	3	22.8	23	23.5	24.5	24.7
33	1	1	34.8	34.7	35	35.2	34.6
38	1	3	25	25	25	24.7	25.2
40	1	2	26.2	26	26	26	26.2
41	1	2	28.2	28.2	27.5	27.7	28
42	1	2	29.8	30	30	29.5	29.5
48	1	2	22.5	22	22.3	21.9	22.4
50	1	2	24.1	24.2	24.3	24.5	24.8
52	1	1	29	28.7	28	27.9	28.2
59	1	2	35.8	35	35.2	34.5	35.2
60	1	1	23.4	23.5	23.8	25	24.9
3	2	2	28.3	28.2	28.7	28.2	28.8
4	2	2	29	28.5	28.5	29	28.8
6	2	1	29.5	29.3	29.5	29.5	29.8
7	2	1	28.2	28.5	28.2	28.2	28
8	2	1	30	30	31.2	30	30.7
14	2	3	32.2	32	31.8	32	31.8
19	2	1	29	29	28.5	29.2	29
20	2	3	23.5	23.8	23.5	23.3	23.5
23	2	1	27.7	27.5	28	27.5	28
27	2	3	27.5	27.7	27.5	27.3	27.3
29	2	3	27.8	28.5	28.5	28	28
30	2	1	24.5	24.5	24.5	24.5	24.5
31	2	2	25	25	25	25.5	25.2
32	2	3	22.7	23	23.5	23.5	24.1
34	2	3	29.5	29	29	29.7	29.5
35	2	2	23	23.2	23.5	23.5	23

36	2	2	29	29	29.2	29.2	29.2
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
37	2	2	26.5	26.5	26.3	26.5	26.5
39	2	1	29	29.2	28.7	28.5	28.7
43	2	1	31.1	31.3	31.5	31	31
44	2	2	27.4	27.9	28	28.6	29
45	2	2	22.7	22.8	22.9	22.6	22.4
46	2	2	25.1	25.4	24.8	24.8	24.7
47	2	1	28.2	27.8	27.5	27.8	28.5
49	2	2	28.6	28.4	28.1	31.5	28.1
51	2	3	30.4	30.7	30.9	31.4	31.3
53	2	1	27.6	27.5	27.5	27.8	27.7
54	2	2	29.6	29.9	29.4	29.5	29.4
55	2	3	24.3	25.1	24.9	25.3	25.7
56	2	3	28.4	28.5	28.5	28.6	28.5
57	2	3	28.6	28.5	28.4	28.3	28.4
58	2	3	32.7	30.1	33.7	33.1	33.6

Appendix C-3. Raw Data for Circumference 12cm. Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6	2	1	30.8	30.8	30.5	30.7	31
7	2	1	30.5	31.2	30.8	30.3	30.3
8	2	1	32	31.2	31.5	31.3	31.7
12	1	1	31.5	31	31.5	31.2	31.3
13	1	1	34.7	34.8	34.2	34.3	35
16	1	1	24.2	24	24.2	24	24.5
17	1	1	28.7	29	28.5	28.7	28.5
18	1	1	30.5	29.7	29.2	29.7	29.5
19	2	1	30.2	30.3	30.5	30.3	30.3
22	1	1	25.3	24.8	25	24.7	25
23	2	1	28.5	29.2	29.3	29.3	29
25	1	1	32.2	32	32	32.2	32.2
30	2	1	25.2	25.2	25.5	25.2	25.3
33	1	1	37.8	37	37.2	37.8	37
39	2	1	30.7	31.2	31	31	31
43	2	1	33	32.7	33	32.2	32.3
47	2	1	29.9	29.7	29.3	29.5	29.7
52	1	1	31.4	31.2	30.5	30.5	31.1
53	2	1	29.1	29	29	29.1	29.1
60	1	1	24.3	25	24.8	25	25
3	2	2	30.3	30	29.7	30.3	30.3
4	2	2	30.7	30.7	30.5	31	30.8
5	1	2	29.2	28.5	29	28.3	29
10	1	2	31.4	31.2	31.6	31	30.9
26	1	2	26.2	26	26.2	26.2	26
31	2	2	27	26.2	26.5	27	27
35	2	2	24.3	24.3	24.5	24.2	24.5
36	2	2	30.5	31	30.8	31	31
37	2	2	27.5	27	27	27	27
40	1	2	27.5	27	27	27	27.2
41	1	2	29.7	29.3	28.8	29.5	29.2
42	1	2	32.3	31.3	31.5	31.3	31.2
44	2	2	28.7	29.4	29.3	30	30.5
45	2	2	24.4	24.6	24.1	24.4	23.8
46	2	2	26.5	26.4	25.8	26.1	26.4
48	1	2	23.5	23.1	23.3	23	23.5
49	2	2	30.1	30.2	29.7	29.8	29.5
50	1	2	25.8	26.2	26.4	26.3	26.4
54	2	2	30.1	30.9	30.8	31	30.1
59	1	2	38.2	37.8	38.2	37.2	38
1	1	3	25.3	24.8	25	25.3	25
2	1	3	27.5	27.3	27.2	27.3	27.3
9	1	3	28	28	27.7	27.7	27.7
11	1	3	28.3	28.7	28.2	27.7	28.2

14	2	3	33.3	33	33	33.3	33
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
15	1	3	27	27.3	27	27.2	27.7
20	2	3	24.8	25.3	25.5	25.3	25.7
21	1	3	26	26.5	26.5	26.8	27
24	1	3	26	26	25.5	25.5	26.2
27	2	3	29	29	29	29	29.2
28	1	3	23.7	24	24	25	25
29	2	3	29.6	30	30	29.8	30
32	2	3	23.5	23.5	23.8	24	24.2
34	2	3	32.3	32.3	31.7	32.7	32.5
38	1	3	26.5	26	26	25.8	26.3
51	2	3	32.3	32.4	32.4	33.5	33.4
55	2	3	25.6	26.2	25.8	26.3	26.2
56	2	3	30.8	30.5	31	31.2	30.6
57	2	3	29.7	29.5	29.3	29.2	29.5
58	2	3	34.6	34.8	35.4	34.9	35.2

Appendix C-4. Raw Data for ProbePost Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6	2	1	35	36	42	45	53
7	2	1	46	39	37	44	50
8	2	1	45	52	58	58	75
12	1	1	48	35	39	42	44
13	1	1	70	69	67	61	67
16	1	1	45	39	53	48	56
17	1	1	34	32	36	46	41
18	1	1	35	35	33	33	29
19	2	1	39	43	48	43	51
22	1	1	33	21	16	22	25
23	2	1	45	38	31	37	39
25	1	1	10	13	13	16	23
30	2	1	33	20	28	27	31
33	1	1	44	36	48	46	51
39	2	1	45	30	46	48	52
43	2	1	49	36	34	47	48
47	2	1	44	43	28	31	42
52	1	1	45	31	30	38	36
53	2	1	52	55	55	57	50
60	1	1	29	24	23	24	39
3	2	2	40	38	41	41	48
4	2	2	32	46	45	47	50
5	1	2	39	33	31	15	37
10	1	2	48	46	48	43	53
26	1	2	25	19	25	30	31
31	2	2	32	23	19	20	33
35	2	2	39	21	30	29	34
36	2	2	47	42	48	46	58
37	2	2	42	38	40	49	47
40	1	2	49	35	42	43	48
41	1	2	37	33	37	37	34
42	1	2	33	26	29	29	32
44	2	2	76	50	60	54	47
45	2	2	40	31	18	19	40
46	2	2	45	32	33	39	32
48	1	2	38	35	28	40	33
49	2	2	37	31	38	39	36
50	1	2	33	27	30	31	36
54	2	2	41	38	38	25	33
59	1	2	52	51	45	47	56
1	1	3	25	24	18	21	25
2	1	3	22	19	22	26	19
9	1	3	52	40	38	43	53
11	1	3	47	32	37	30	26

14	2	3	38	32	30	30	35
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
15	1	3	33	30	34	36	41
20	2	3	42	28	44	48	35
21	1	3	38	27	25	27	30
24	1	3	20	23	17	27	25
27	2	3	36	30	35	39	38
28	1	3	30	23	16	21	28
29	2	3	35	22	24	34	33
32	2	3	21	13	11	15	31
34	2	3	41	36	42	39	38
38	1	3	39	13.4	40	40	43
51	2	3	42	36	35	40	40
55	2	3	33	33	36	32	42
56	2	3	53	49	42	45	41
57	2	3	51	50	61	48	46
58	2	3	64	50	57	57	57

Appendix C-5. Raw Data for Resting Joint Angle Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6	2	1	33	35	36	38	32
7	2	1	26	22	24	26	24
8	2	1	45	44	42	39	41
12	1	1	33	31	29	29	30
13	1	1	31	28	22	26	23
16	1	1	20	24	24	24	21
17	1	1	32	32	31	33	32
18	1	1	32	27	28	23	23
19	2	1	27	33	26	26	26
22	1	1	30	30	28	41	24
23	2	1	33	35	36	35	36
25	1	1	28	32	31	28	25
30	2	1	27	30	28	26	25
33	1	1	22	21	22	23	22
39	2	1	31	27	28	30	26
43	2	1	21	21	21	20	21
47	2	1	23	25	23	22	23
52	1	1	24	21	21	18	17
53	2	1	43	39	34	37	30
60	1	1	50	55	49	37	28
3	2	2	29	28	24	28	28
4	2	2	11	18	24	22	18
5	1	2	52	38	32	39	32
10	1	2	26	23	21	22	25
26	1	2	20	25	23	21	25
31	2	2	32	34	35	39	30
35	2	2	25	25	26	25	26
36	2	2	30	27	27	27	28
37	2	2	27	24	31	26	28
40	1	2	29	26	29	27	23
41	1	2	25	22	24	22	21
42	1	2	42	40	36	35	39
44	2	2	37	38	36	33	35
45	2	2	21	27	32	24	25
46	2	2	20	21	22	21	20
48	1	2	25	25	26	24	23
49	2	2	24	26	26	25	28
50	1	2	34	38	35	40	28
54	2	2	23	23	20	21	31
59	1	2	18	26	22	26	26
1	1	3	28	30	23	25	21
2	1	3	9	19	20	19	19
9	1	3	46	42	38	39	36
11	1	3	36	36	34	33	37

14	2	3	33	31	31	38	30
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
15	1	3	31	33	31	35	33
20	2	3	44	38	39	40	39
21	1	3	35	36	36	37	35
24	1	3	21	22	22	21	20
27	2	3	34	34	33	31	32
28	1	3	40	35	41	42	29
29	2	3	37	34	35	29	33
32	2	3	42	35	37	35	35
34	2	3	26	22	24	23	23
38	1	3	22	23	23	24	20
51	2	3	29	25	21	21	20
55	2	3	21	25	23	20	15
56	2	3	21	24	25	23	25
57	2	3	23	20	20	21	26
58	2	3	32	27	30	30	30

Appendix C-6. Raw Data for Visual Analogue Scale Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6	2	1	10	8.8	9	8.3	5.5
7	2	1	8.8	8.1	7.5	6.3	5.4
8	2	1	0.4	0	1	0	0
12	1	1	6.5	7.7	3.9	2.7	0.5
13	1	1	1.2	2.6	3.1	3.3	2.7
16	1	1	1.8	2	1.8	0.8	0
17	1	1	0.6	3.7	2.7	0.3	0
18	1	1	6.3	2.9	2.6	0.8	0.5
19	2	1	0.7	0.6	0.7	0.7	0.7
22	1	1	3.9	7.1	9.2	9.8	6.2
23	2	1	0.7	1.7	2.1	1.9	1.5
25	1	1	2	7.3	6.9	6	3.2
30	2	1	0.7	6	1.4	0	0
33	1	1	0.9	0.8	0.5	0.3	0.2
39	2	1	1.4	1	0.6	0.3	0.1
43	2	1	1.6	2.7	2.1	1.1	0.4
47	2	1	6.5	2.6	3.4	2.1	1
52	1	1	3	5.3	6.6	6.1	2.6
53	2	1	4.4	5.7	3.7	6.2	4.6
60	1	1	0.6	3.4	4.2	5.5	1.6
3	2	2	1.9	3.3	3.1	2	1.9
4	2	2	0.8	4.2	3.8	1.4	1.1
5	1	2	8.3	9	9.1	9.4	8.5
10	1	2	0.5	0.8	1.2	0.4	0.2
26	1	2	1.6	2.1	2.4	1.9	1.5
31	2	2	3.5	5.9	2.7	4	2.4
35	2	2	3.1	4.6	5	3.7	1.6
36	2	2	1	3.7	4.8	2.1	0.9
37	2	2	1.4	1	0.9	0.4	0.3
40	1	2	1.5	2	2.7	1.2	0.3
41	1	2	0	1.7	1.3	0.5	0
42	1	2	7.1	5.9	4	5.3	1.6
44	2	2	0.6	3.6	3.5	3.2	3.3
45	2	2	10	6.2	5.6	3.9	1.5
46	2	2	1.1	2.2	2.7	1.1	0.4
48	1	2	0	3.4	1.3	0	0
49	2	2	0.1	0.5	0.1	0.2	0.1
50	1	2	6.5	4.2	4	5.5	2.9
54	2	2	1.3	3.2	3.5	3.7	2.6
59	1	2	1.2	6.5	5.7	4.6	1.1
1	1	3	1.3	0.3	0.4	0.3	0.3
2	1	3	2.2	0.2	6.4	3.6	0.2
9	1	3	2.5	2.6	2	2	1
11	1	3	5.7	5.5	5.7	6.2	4.5

14	2	3	3.7	6.1	5.5	3.3	2.1
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
15	1	3	0.1	1.5	1.3	0.4	0.2
20	2	3	9.5	7	2.9	0.7	0
21	1	3	0.9	2.6	2.2	2.9	3.5
24	1	3	1.8	2	1	0.2	0
27	2	3	0.5	1.6	1.5	0.7	0
28	1	3	3	4.4	5.8	5.2	3.8
29	2	3	1.9	3.1	3.5	1.3	1
32	2	3	6.9	5.7	4.5	8.1	5.5
34	2	3	0.6	2.5	1.6	1.5	0.4
38	1	3	3.7	6	2.8	0.6	0.1
51	2	3	1.8	3.4	3.2	3.5	2.1
55	2	3	1.2	1.1	0.7	0.8	0.4
56	2	3	0.1	0.5	0.7	0.3	0.1
57	2	3	0	0	0	0	0
58	2	3	0	1.5	1.1	0	0

Appendix C-7. Raw Data for Strength Post Treatment

Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
6.0	2.0	1	31.0	25.3	25.7	26.7	25.6
7.0	2.0	1	30.3	30.7	33.1	31.3	30.8
8.0	2.0	1	17.2	33.9	39.8	38.1	42.6
12.0	1.0	1	35.2	39.4	55.7	64.4	56.6
13.0	1.0	1	36.1	41.5	40.2	50.3	51.1
16.0	1.0	1	14.7	20.4	19.3	19.3	14.0
17.0	1.0	1	62.5	60.4	58.9	60.9	57.0
18.0	1.0	1	28.5	32.8	24.6	22.0	29.8
19.0	2.0	1	35.8	36.5	44.1	43.7	49.5
22.0	1.0	1	16.0	7.6	7.5	4.6	7.6
23.0	2.0	1	23.5	24.7	25.8	24.1	23.5
25.0	1.0	1	26.5	42.3	56.5	56.9	59.4
30.0	2.0	1	17.7	16.0	24.5	29.8	56.0
33.0	1.0	1	63.3	76.7	84.1	65.9	80.2
39.0	2.0	1	50.4	51.9	57.0	55.6	56.5
43.0	2.0	1	52.3	43.7	51.9	56.3	48.2
47.0	2.0	1	32.7	41.6	31.8	48.8	40.7
52.0	1.0	1	17.8	28.9	34.2	37.3	41.7
53.0	2.0	1	24.8	29.4	45.4	46.2	33.6
60.0	1.0	1	22.0	20.9	24.8	19.9	26.7
3.0	2.0	2	2.5	41.1	48.9	54.2	49.2
4.0	2.0	2	45.0	45.5	39.3	36.1	34.7
		2	18.6	18.8	16.0	20.8	20.4

5.0	1.0						
10.0	1.0	2	52.1	56.9	58.7	72.3	74.4
26.0	1.0	2	12.6	14.4	11.6	14.8	16.8
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
31.0	2.0	2	8.2	7.7	12.5	10.1	12.5
35.0	2.0	2	17.0	22.7	24.8	28.6	26.3
36.0	2.0	2	53.0	57.0	64.7	63.1	61.4
37.0	2.0	2	18.9	21.1	22.6	24.3	22.7
40.0	1.0	2	18.2	14.9	18.4	17.2	25.3
41.0	1.0	2	17.6	43.0	44.8	43.6	55.4
42.0	1.0	2	26.7	36.4	45.1	45.7	66.6
44.0	2.0	2	17.1	20.4	19.7	19.7	15.8
45.0	2.0	2	3.9	1.7	2.2	9.8	10.9
46.0	2.0	2	11.1	12.0	15.0	16.9	15.1
48.0	1.0	2	13.1	19.0	19.6	19.8	22.0
49.0	2.0	2	38.9	56.9	54.3	55.5	46.5
50.0	1.0	2	7.3	10.0	12.5	10.7	11.6
54.0	2.0	2	23.9	24.6	27.6	26.4	33.5
59.0	1.0	2	31.0	37.0	25.9	25.9	33.4
1.0	1.0	3	6.5	15.6	21.2	17.6	15.1
2.0	1.0	3	10.5	12.2	17.1	14.6	17.3
9.0	1.0	3	18.5	22.4	31.5	31.9	34.7
11.0	1.0	3	3.7	3.1	7.7	6.7	
14.0	2.0	3	59.1	58.0	69.1	74.5	76.0
15.0	1.0	3	7.4	10.6	6.5	13.2	16.3

20.0	2.0	3	13.4	10.4	20.1	21.9	21.3
21.0	1.0	3	18.5	15.6	22.7	22.7	21.3
24.0	1.0	3	11.9	17.3	15.7	14.6	15.8
27.0	2.0	3	36.3	36.3	32.1	37.8	39.2
28.0	1.0	3	8.4	2.5	5.2	12.3	17.5
Sub #	Treat	Group	Post Treatment Day 1	Post Treatment Day 2	Post Treatment Day 3	Post Treatment Day 4	Post Treatment Day 5
29.0	2.0	3	36.3	40.5	30.4	35.9	43.2
32.0	2.0	3	14.7	13.8	22.7	6.1	7.2
34.0	2.0	3	27.7	26.9	27.5	23.5	22.8
38.0	1.0	3	16.0	39.0	14.6	11.1	13.6
51.0	2.0	3	48.0	46.8	56.3	65.6	74.8
55.0	2.0	3	8.5	16.9	18.7	17.5	14.7
56.0	2.0	3	19.3	22.9	28.0	25.4	20.6
57.0	2.0	3	69.6	63.0	64.7	65.2	61.7
58.0	2.0	3	70.6	81.0	87.7	85.6	83.4

Appendix C-8. Raw Data for Circumference 4 cm. (Pre treatment – Post-treatment)

Subj. #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
6	2	1	-0.8	0.5	-1	-0.3	0
7	2	1	-0.5	0.1	0.4	0.2	-0.3
8	2	1	-0.4	-1	0.2	-0.3	0.5
12	1	1	0.3	0	0.7	0	0.5
13	1	1	-0.2	0	-0.5	0.3	1.7
16	1	1	-0.2	0.2	0	0	0.5
17	1	1	-0.3	0	-0.5	0.2	0
18	1	1	-0.3	0.5	0.3	0.5	1.1
19	2	1	-0.3	0	0.3	1	-0.3
22	1	1	-0.2	0	0	0.2	0.5
23	2	1	-0.1	0.4	0.3	0	0
25	1	1	-1.2	-0.3	-0.7	-0.6	0
30	2	1	-0.3	0	0	0.4	0.3
33	1	1	0	-0.6	-0.3	-0.4	0.1
39	2	1	-0.2	0.5	-0.5	0.1	0.3
43	2	1	0.1	0.2	1.2	0.3	-0.1
47	2	1	0.5	0.1	0.1	-0.9	0.3
52	1	1	0	0	-0.3	-0.4	0.1
53	2	1	-0.6	-0.2	-0.5	0.2	1.3
60	1	1	-0.9	-0.7	-1.6	-0.1	2.7
3	2	2	-1.8	-0.1	-0.5	-1.5	1.2
4	2	2	-0.2	0.4	-0.6	0.2	0.5
5	1	2	-1	-0.2	0	0.1	1.2
10	1	2	-0.1	-0.4	0.1	-0.5	-0.5
26	1	2	0	0.2	-0.3	0	-0.3
31	2	2	-0.7	0	-1	0.2	0.2
35	2	2	-0.7	0.2	0	-0.2	0.5
36	2	2	0	-0.2	0	0	0
37	2	2	0	-0.2	0	0	0.5
40	1	2	0	0	-0.5	0	0.7
41	1	2	-0.2	0.7	0	0	0
42	1	2	-1	-0.2	0.5	0	1
44	2	2	-0.9	-0.4	-0.6	-0.7	2.4
45	2	2	-0.4	0	0	0.5	0.2
46	2	2	-0.2	-0.2	-0.3	-0.3	-0.2
48	1	2	-0.8	0.1	-0.1	0.2	-0.4
49	2	2	1.8	2.3	0.4	0.3	0.6
50	1	2	-0.2	-0.1	-0.4	-0.2	0.8
54	2	2	1.7	1.4	-0.4	0.6	-0.2
59	1	2	0.4	-1.5	0.5	-0.3	0.6
1	1	3	-0.8	0.2	-0.7	-0.3	0.5
2	1	3	-0.7	0	0.2	0.3	1.2
9	1	3	-0.7	0.1	-0.2	0	0.8
11	1	3	0.3	0.1	0.7	-0.3	0.5
14	2	3	0.2	-0.2	0.3	0	0

15	1	3	0	0.3	0.3	-0.3	0.3
Subj. #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
20	2	3	-0.7	0.3	0.2	0	0.7
21	1	3	-0.2	-0.2	-1	0	2.1
24	1	3	-0.2	0.5	0	0.2	-1
27	2	3	-0.2	-0.2	-0.2	0	0
28	1	3	-0.7	-0.5	-1.5	0	2.7
29	2	3	-0.5	0.3	0.6	-0.5	-0.5
32	2	3	-0.5	-0.9	-0.7	-0.3	1.5
34	2	3	0	0	-0.3	0	0.5
38	1	3	-0.3	0	0.2	-0.5	-0.5
51	2	3	-0.4	-0.1	-0.2	0.3	0.9
55	2	3	-0.7	0	-0.3	-0.7	1.7
56	2	3	-0.5	0	0	0.4	0.5
57	2	3	-0.7	-0.2	0.6	0.1	0.5
58	2	3	-1.1	0.1	0.1	0.3	1

Appendix C-9. Raw Data for Circumference 8 cm. (Pre treatment – Post-treatment)

Sub #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
6	2	1	-0.8	0.2	-0.3	0.2	-0.1
7	2	1	0	-0.3	0	0	0.2
8	2	1	-1	0	-1	0.2	-0.2
12	1	1	-0.1	0.7	0	0	0.5
13	1	1	0	-0.5	0.2	0.7	-0.5
16	1	1	0	0	0	-0.2	0
17	1	1	-0.5	-0.2	0.2	0.2	0
18	1	1	-0.5	0	0.3	-0.2	0
19	2	1	0	0	0.5	0.3	0
22	1	1	-0.2	-0.1	-0.3	0.4	0
23	2	1	-0.2	0.2	-0.5	-0.2	-0.3
25	1	1	-0.3	-0.5	0.7	-0.5	-1.1
30	2	1	0	0.3	0	0	0
33	1	1	-0.3	0.3	-0.5	0	0.2
39	2	1	0	-0.2	0.1	0.5	-0.5
43	2	1	0	0.2	0.4	0.4	-0.3
47	2	1	0.2	-0.2	0.6	0	0.1
52	1	1	-0.8	-0.6	0.3	0.5	-0.3
53	2	1	-0.8	0	0	-0.4	0.3
60	1	1	-0.7	0	-0.1	0.1	0
3	2	2	-0.8	-0.4	-0.5	0.1	0
4	2	2	-0.2	0.7	0.2	0.2	0.4
5	1	2	-0.5	0	-0.5	0.2	-0.2
10	1	2	-0.4	0	-0.9	-0.6	0
26	1	2	-0.3	-0.2	0	0	0
31	2	2	-0.4	0	0	0	0.1
35	2	2	-0.3	0	-0.3	-0.5	0
36	2	2	0	0.2	0.3	-0.2	-0.2
37	2	2	-0.2	0	0.2	-0.5	0
40	1	2	-0.2	0	0	0	0.3
41	1	2	-0.2	-0.2	0	-0.2	-0.5
42	1	2	-0.8	0	0	0.2	0
44	2	2	-0.4	0	0	-0.2	0
45	2	2	-0.1	-0.2	0	0.2	0
46	2	2	-0.3	-0.2	-0.1	-0.1	-0.1
48	1	2	-0.2	0.4	-0.1	0.3	-0.2
49	2	2	-0.1	0.5	0.3	-2.8	0.5
50	1	2	0.1	0.5	0.1	0.1	0.2
54	2	2	0.1	0.1	0.2	0	-0.2
59	1	2	-0.6	0.9	-0.2	0.6	0.5
1	1	3	-1	-0.3	0	0	0
2	1	3	-1.5	0.5	0.5	-0.1	0.5
9	1	3	-0.5	0	-0.3	0.2	0.3
11	1	3	0.5	0.1	-0.2	0.2	0.2

14	2	3	-0.4	0	0.2	0	-0.1
Sub #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
15	1	3	-0.2	0	0.2	-0.2	0.4
20	2	3	0	-0.3	-0.2	-0.1	0
21	1	3	-0.2	-0.2	0.3	0	0.2
24	1	3	-0.5	0.2	0.3	0.3	-0.2
27	2	3	0	-0.2	-0.2	0.2	0
28	1	3	-0.3	0.3	0	0	0.1
29	2	3	-0.3	-0.2	0	0.2	0
32	2	3	-0.2	0	-0.5	0.5	-0.1
34	2	3	-0.5	0.5	0.2	-0.7	0
38	1	3	-0.5	0	-0.2	0.3	-0.2
51	2	3	-0.2	0.2	0.2	0.5	-0.3
55	2	3	0.1	0.1	0	-0.1	0.1
56	2	3	-0.5	-0.1	0.3	0.4	0.2
57	2	3	-0.3	-0.2	0	0.1	0
58	2	3	-0.6	3.5	-0.3	0.1	-0.2

Appendix C-10. Raw Data for Circumference 12 cm. (Pre treatment – Post-treatment)

Sub #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
6	2	1	-0.5	0.2	2.8	0.1	-0.5
7	2	1	0.3	0	0	3	0.2
8	2	1	-1.5	0.1	-0.5	0.2	0
12	1	1	0.2	0.5	0.3	-0.2	0.2
13	1	1	-0.2	-0.5	-0.2	0.5	0
16	1	1	-0.2	0.2	-0.2	0	-0.5
17	1	1	-0.2	-0.2	-0.2	0.3	0.5
18	1	1	-0.5	0.3	0.5	-0.5	0
19	2	1	0.5	0.2	0.2	0.5	0.2
22	1	1	-0.6	0.9	-0.3	0.1	0.2
23	2	1	0.7	0	0	0	0.5
25	1	1	-0.7	0	0	-0.7	-0.4
30	2	1	0.6	0.3	0	0.6	0.2
33	1	1	-0.6	0	-0.2	-0.5	0.2
39	2	1	0.3	-0.2	-0.2	-0.5	-0.5
43	2	1	-0.3	0.2	0.2	0.3	-2.2
47	2	1	0	-0.1	0.2	-0.2	0.5
52	1	1	0	-0.5	0.1	0.3	-0.1
53	2	1	-0.5	0	-0.1	-0.2	0.1
60	1	1	-0.3	-0.5	-0.3	0.7	0.1
3	2	2	-0.5	-0.5	0.5	-0.5	0.4
4	2	2	-0.7	0.1	-0.5	0	0.2
5	1	2	-1.2	0	-0.2	0.5	-0.2
10	1	2	-0.4	-0.4	-0.5	-0.7	0.3
26	1	2	0	0	-0.2	0.1	-0.2
31	2	2	-0.2	0.3	0	0	0
35	2	2	-0.6	0.2	0	-0.2	-0.3
36	2	2	0.2	-0.3	0.2	-0.3	-0.2
37	2	2	-0.7	0.2	0	0	0
40	1	2	0.3	0	0.3	0	0.1
41	1	2	-0.4	0.7	0	-0.3	-0.2
42	1	2	-1.8	0.4	0.2	-0.1	0.3
44	2	2	0.3	0.1	0.1	-0.2	-0.3
45	2	2	-0.3	-0.5	0.3	-0.4	0.1
46	2	2	0.1	0.4	0.5	0.1	-0.5
48	1	2	-0.4	-0.2	-0.1	0	-0.4
49	2	2	-0.1	0.2	0	3.5	0.8
50	1	2	0.5	0.6	-0.3	0	0.3
54	2	2	1.3	0.5	0.1	0.2	0.3
59	1	2	-0.4	0.7	-0.3	0.6	-0.7
1	1	3	-0.2	0.2	0	-0.1	0.3
2	1	3	-2.2	0.5	-0.2	0.4	0.5
9	1	3	0	0	-0.2	0.3	0.3
11	1	3	0.7	-0.4	0	0.3	-0.2
14	2	3	-0.3	0	0.3	-0.3	-0.3

15	1	3	0	0.7	1	-0.2	0
Sub #	Treat	Group	Delta Day 1	Delta Day 2	Delta Day 3	Delta Day 4	Delta Day 5
20	2	3	0.7	0	-0.5	-0.1	0.3
21	1	3	0	-0.2	0	-0.1	0.2
24	1	3	-0.3	-0.5	0.5	0.3	-0.7
27	2	3	0.2	0	-0.2	0	-0.2
28	1	3	-0.2	0	0	0	0
29	2	3	-0.1	0	0	-0.3	-0.3
32	2	3	0	-0.2	-0.3	0	-0.2
34	2	3	-0.1	-0.1	0.5	-0.4	-0.3
38	1	3	-0.5	0	0.2	0.2	-0.3
51	2	3	-0.6	0.3	0.3	0.7	-0.2
55	2	3	-0.1	0	0.1	0.1	0.1
56	2	3	-0.6	0.2	-0.3	-0.3	0
57	2	3	-0.3	0	0.2	0.1	0
58	2	3	0.3	0.4	-0.3	0.2	0.2

Appendix C-11. Raw Data for Probe (Pre treatment – Post-treatment)

Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
6	2	1	19	15	0	2	0
7	2	1	15	8	14	-3	-8
8	2	1	-5	-4	1	4	-4
12	1	1	12	7	0	-3	5
13	1	1	-4	3	-2	-2	-2
16	1	1	6	5	-13	3	4
17	1	1	0	-5	2	-10	3
18	1	1	3	0	4	5	6
19	2	1	43	-3	-1	1	-2
22	1	1	1	-1	5	1	4
23	2	1	-1	-3	3	-3	-2
25	1	1	22	0	-3	-4	6
30	2	1	6	3	-3	2	2
33	1	1	-2	8	-4	-2	-3
39	2	1	3	9	-3	-3	-1
43	2	1	5	-1	9	7	2
47	2	1	8	-7	-10	8	-1
52	1	1	-4	6	9	-3	3
53	2	1	27	2	8	-1	6
60	1	1	6	0	0	-5	-9
3	2	2	4	4	7	7	3
4	2	2	6	3	9	9	1
5	1	2	-2	-6	-3	10	-7
10	1	2	7	9	1	8	2
26	1	2	12	0	-1	0	-1
31	2	2	4	-4	0	2	-3
35	2	2	2	5	-3	5	4
36	2	2	8	4	0	3	3
37	2	2	3	-4	0	2	2
40	1	2	3	0	3	-1	-2
41	1	2	-6	-2	0	1	6
42	1	2	3	2	-2	2	4
44	2	2	-3	5	-6	-4	4
45	2	2	15	5	8	12	-3
46	2	2	2	5	-1	-4	6
48	1	2	-1	0	2	5	4
49	2	2	1	8	1	-4	-1
50	1	2	2	-3	1	5	-6
54	2	2	4	2	4	11	-1
59	1	2	2	-7	9	1	-2
1	1	3	8	-11	7	4	-1
2	1	3	8	6	-6	2	6
9	1	3	10	4	8	11	0
11	1	3	5	-2	-1	3	-4
14	2	3	19	1	2	-1	-4

15	1	3	3	8	0	2	-3
Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
20	2	3	9	3	-2	-4	9
21	1	3	3	3	-5	-8	1
24	1	3	15	-4	6	-4	2
27	2	3	1	0	-4	-4	4
28	1	3	13	-2	-3	-7	1
29	2	3	2	6	3	-4	5
32	2	3	1	0	-1	-2	-12
34	2	3	5	2	-5	-5	2
38	1	3	3	2.8	-1	-1	1
51	2	3	-1	10	-1	-3	0
55	2	3	6	-7	1	4	-2
56	2	3	13	8	8	1	9
57	2	3	2	9	-10	1	0
58	2	3	11	17	2	9	5

Appendix C-12. Raw Data for Resting Joint Angle (Pre treatment – Post-treatment)

Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
6	2	1	-8	1	0	7	9
7	2	1	-8	3	1	1	1
8	2	1	-8	2	3	3	2
12	1	1	-7	-1	0	0	0
13	1	1	-6	-1	1	-3	7
16	1	1	3	0	-1	0	2
17	1	1	-1	-2	-1	-2	-2
18	1	1	-7	3	2	3	4
19	2	1	2	-4	2	1	3
22	1	1	-10	0	-1	6	-1
23	2	1	2	-2	0	1	-1
25	1	1	2	-1	0	3	6
30	2	1	-2	-5	-1	4	5
33	1	1	3	0	1	-1	-1
39	2	1	-4	1	0	-3	0
43	2	1	10	3	4	0	1
47	2	1	-3	0	0	0	0
52	1	1	-3	4	1	4	3
53	2	1	-18	-4	4	3	4
60	1	1	-25	-1	7	13	6
3	2	2	-6	7	3	-2	3
4	2	2	-6	-1	-2	0	-1
5	1	2	-26	-7	1	1	5
10	1	2	-6	-2	3	2	-5
26	1	2	5	1	0	3	1
31	2	2	-8	1	0	-2	-5
35	2	2	-3	1	-1	0	-1
36	2	2	-4	-1	0	0	0
37	2	2	0	3	0	2	4
40	1	2	-9	4	-3	-1	3
41	1	2	-4	2	-1	-1	0
42	1	2	-5	-1	5	1	-4
44	2	2	-17	-3	1	1	2
45	2	2	-1	1	-4	2	0
46	2	2	3	1	4	2	1
48	1	2	-2	1	-1	4	2
49	2	2	-2	-3	2	0	-2
50	1	2	-14	-2	3	1	7
54	2	2	-3	0	2	0	-10
59	1	2	10	11	2	-1	3
1	1	3	-8	1	7	0	7
2	1	3	-4	1	2	3	1
9	1	3	-13	2	4	3	2
11	1	3	-11	3	0	0	4
14	2	3	-1	3	0	-6	-3

15	1	3	1	1	3	-3	-2
Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
20	2	3	5	-1	2	-6	3
21	1	3	-9	-1	2	-1	6
24	1	3	-2	0	-1	1	1
27	2	3	1	2	1	0	-2
28	1	3	-20	2	-1	-1	3
29	2	3	-8	3	0	4	0
32	2	3	-9	6	3	0	0
34	2	3	5	0	1	-2	2
38	1	3	-1	0	-2	-2	3
51	2	3	-7	-1	0	-1	0
55	2	3	-9	-2	4	0	4
56	2	3	-2	1	0	6	1
57	2	3	-3	4	3	2	1
58	2	3	-5	3	-3	-2	0

Appendix C-13. Raw Data for Visual Analogue Scale (Pre treatment – Post-treatment)

Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
6	2	1	-9.2	1	-0.1	0.3	0.1
7	2	1	-8.7	0.8	0.1	0.9	0.9
8	2	1	-0.4	0	-0.4	0	0
12	1	1	-6.5	-1	0.7	-0.3	0.9
13	1	1	-0.7	1.1	-0.1	-0.4	1.2
16	1	1	-1.8	-0.1	0.3	0.8	0
17	1	1	-0.6	1.2	-0.1	0.1	0
18	1	1	-5.6	0.6	-0.3	0.6	-0.1
19	2	1	-0.7	0.8	1.1	0	-0.3
22	1	1	-3.8	-0.6	-0.8	0	1.3
23	2	1	-0.7	-0.2	0.2	0.2	0.1
25	1	1	-2	-0.7	-1.5	0.5	0.6
30	2	1	-0.7	-1.1	0	0.1	0
33	1	1	-0.9	0.2	0.3	0.2	-0.2
39	2	1	-1.4	0.2	0	0.1	0
43	2	1	-1.6	0.4	0	-0.1	0
47	2	1	-6.5	1.1	4.6	1.6	0.2
52	1	1	-3	-0.5	0.6	-1.3	-0.5
53	2	1	-4.4	-1	0.9	0.1	0.2
60	1	1	-0.6	-0.4	2.6	0.9	1.6
3	2	2	-1.9	0.8	-1.1	1.3	-0.1
4	2	2	-0.8	1.1	0	0.7	0.4
5	1	2	-7.6	-0.1	0.4	0	-1.3
10	1	2	-0.5	0.3	0.3	0	0
26	1	2	-1.6	0.1	0	-0.1	-0.6
31	2	2	-3.2	-3.2	0.4	0.8	-0.2
35	2	2	-3.1	1	0	0.1	0.2
36	2	2	-1	2.3	0.2	0.2	0.2
37	2	2	-1.4	0.9	0.2	0.3	0
40	1	2	-1.5	0.7	0.3	0.4	-0.2
41	1	2	0	-0.6	0.7	0	0
42	1	2	-6.9	-2.2	-0.1	-1.2	-0.3
44	2	2	-0.6	1.7	0.3	0.4	0.9
45	2	2	-10	0.5	0.5	0.4	0.8
46	2	2	-1.1	0.4	-0.6	-0.1	-0.2
48	1	2	0	-2.3	0.1	0	0
49	2	2	-0.1	0.5	0.3	0.1	0
50	1	2	-6.5	1.2	2.1	-0.5	-0.1
54	2	2	-1.3	-0.2	0.4	-1.1	-1.9
59	1	2	-1.2	-2.5	0.2	-0.3	0.2
1	1	3	-1.3	0	0	0	0
2	1	3	-2.2	0	1.2	1.4	0
9	1	3	-2.5	0.3	0.1	0	0.1
11	1	3	-5.7	0.8	1.5	-2.1	-0.3
14	2	3	-3.7	-0.7	0.9	0.2	0.1

15	1	3	-0.1	-0.2	1.8	-0.2	0
Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
20	2	3	-9.5	-1.1	0.3	-0.1	0
21	1	3	-0.9	-1.5	0.2	0.1	-0.3
24	1	3	-1.8	0	-0.6	0	0
27	2	3	-0.1	-1	0.4	0	0.3
28	1	3	-3	0.5	0.3	0.5	-0.4
29	2	3	-1.9	1	0.7	0.7	-0.2
32	2	3	-6.9	1.7	0.6	1.4	1.1
34	2	3	-0.6	0.1	0.1	-0.4	0.1
38	1	3	-3.7	0.4	0.6	0.5	1.1
51	2	3	-1.3	0.1	0.8	0.2	0.2
55	2	3	-1.2	0.2	0.3	0	0.1
56	2	3	0	0	-0.2	0.8	-0.1
57	2	3	0	0	0	0	0
58	2	3	0	-0.7	0	0	0

Appendix C-14. Raw Data for Visual Analogue Scale (Pre treatment – Post-treatment)

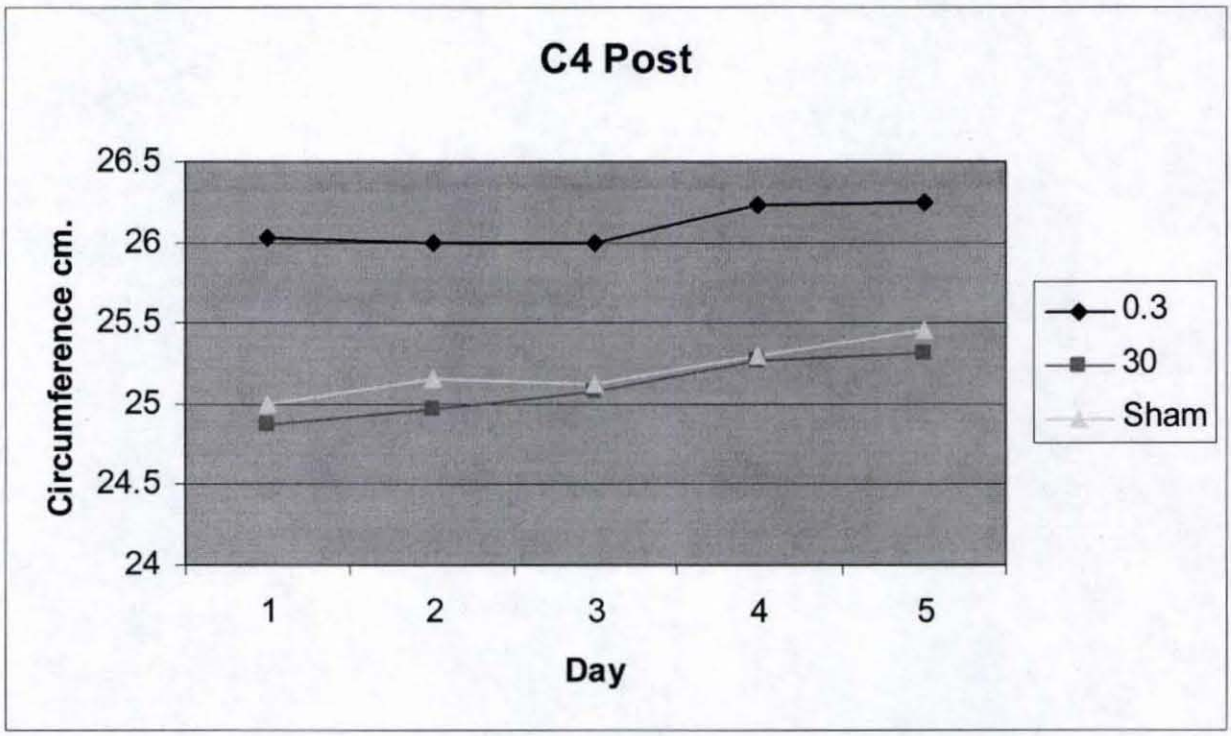
Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
6.0	2.0	1	11.7	(2.6)	5.1	(5.0)	0.9
7.0	2.0	1	6.2	(1.5)	2.8	(0.3)	2.1
8.0	2.0	1	27.7	0.2	2.5	6.8	8.9
12.0	1.0	1	14.2	3.7	2.8	1.2	4.1
13.0	1.0	1	20.9	7.1	0.5	0.9	3.9
16.0	1.0	1	3.4	(4.7)	(7.7)	(7.7)	7.4
17.0	1.0	1	(1.0)	(4.7)	(1.1)	(0.7)	1.0
18.0	1.0	1	8.9	(9.0)	(16.3)	9.8	(4.5)
19.0	2.0	1	12.0	6.8	(2.0)	1.5	(6.7)
22.0	1.0	1	1.6	2.2	1.6	(0.4)	2.6
23.0	2.0	1	(9.9)	2.0	6.4	8.2	3.8
25.0	1.0	1	35.4	14.1	(1.4)	(1.8)	4.1
30.0	2.0	1	3.1	7.8	4.3	(0.6)	(24.6)
33.0	1.0	1	(3.6)	(3.0)	(8.8)	25.9	(9.3)
39.0	2.0	1	5.4	1.7	(0.4)	1.6	(4.6)
43.0	2.0	1	(3.0)	(0.5)	4.3	(6.8)	2.8
47.0	2.0	1	10.4	3.5	(3.1)	1.2	11.5
52.0	1.0	1	19.8	0.7	(2.2)	(1.4)	(4.5)
53.0	2.0	1	16.6	1.7	2.9	0.2	6.7
60.0	1.0	1	17.5	(1.7)	(5.2)	5.0	0.3
3.0	2.0	2	51.6	(3.8)	(2.1)	7.6	3.0
4.0	2.0	2	(2.8)	2.7	6.8	10.9	2.2
5.0	1.0	2	19.3	9.1	(0.9)	4.9	(4.5)

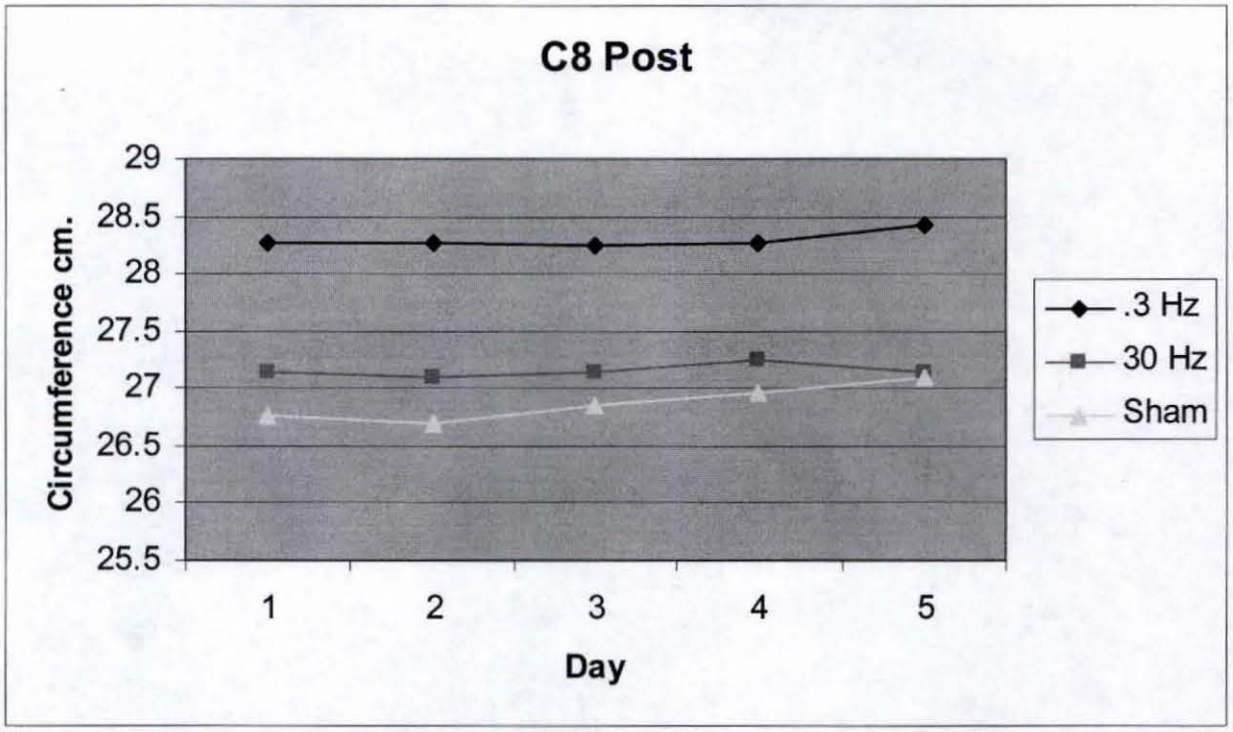
10.0	1.0	2	0.9	(0.5)	(0.6)	(2.9)	8.2
26.0	1.0	2	1.3	(5.6)	0.5	2.3	6.7
Sub #	Treat	Group	Delta Day 1	Delta D2	Delta D3	Delta D4	delta D5
31.0	2.0	2	11.7	3.9	1.4	1.8	(1.1)
35.0	2.0	2	14.4	1.8	3.3	3.0	2.2
36.0	2.0	2	14.4	0.4	(1.1)	(2.3)	9.5
37.0	2.0	2	5.6	(1.1)	2.9	(1.3)	0.4
40.0	1.0	2	4.9	9.5	(1.4)	(0.1)	4.3
41.0	1.0	2	19.6	(13.8)	1.3	4.6	(7.8)
42.0	1.0	2	28.4	15.2	5.7	4.4	(14.3)
44.0	2.0	2	21.4	2.5	0.9	1.4	4.8
45.0	2.0	2	15.1	4.6	2.0	-	1.3
46.0	2.0	2	6.9	2.5	0.3	(0.6)	(1.7)
48.0	1.0	2	(0.1)	(3.6)	(0.6)	0.8	(3.1)
49.0	2.0	2	0.1	1.3	(2.0)	(4.0)	3.2
50.0	1.0	2	12.7	(0.6)	(0.8)	1.7	0.8
54.0	2.0	2	1.9	(4.3)	1.3	2.0	(5.6)
59.0	1.0	2	3.4	5.1	5.5	5.5	(4.9)
1.0	1.0	3	15.6	0.4	2.4	(5.8)	(0.1)
2.0	1.0	3	(4.9)	1.5	(2.3)	(0.1)	4.6
9.0	1.0	3	2.9	0.6	(1.0)	7.7	2.8
11.0	1.0	3	14.4	4.7	(0.8)	0.1	-
14.0	2.0	3	1.4	11.8	10.4	17.7	5.0
15.0	1.0	3 3	0.5	2.9	4.5	(0.1)	(7.4)

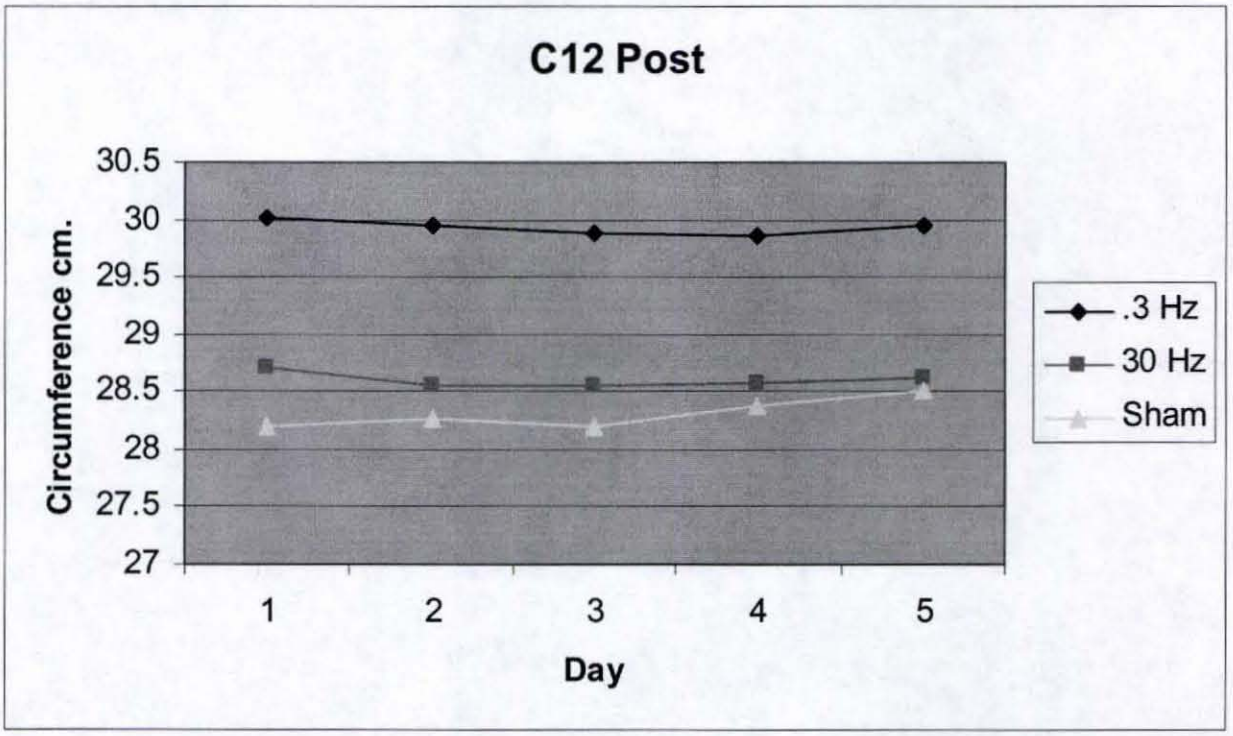
20.0	2.0		8.4	5.8	5.6	0.6	0.9
21.0	1.0	3	10.9	4.1	1.5	1.5	2.5
24.0	1.0	3	3.6	5.9	(2.7)	3.6	(1.5)
27.0	2.0	3	4.4	-	3.6	2.5	(0.2)
28.0	1.0	3	7.9	1.9	0.8	(1.4)	(12.3)
29.0	2.0	3	10.0	(1.2)	0.6	(1.8)	(2.0)
32.0	2.0	3	4.1	(1.2)	(11.0)	(0.3)	(0.6)
34.0	2.0	3	7.8	2.0	5.9	3.1	6.0
38.0	1.0	3	7.5	-	1.2	3.2	0.1
51.0	2.0	3	30.5	7.2	6.6	(4.4)	(7.4)
55.0	2.0	3	20.8	(0.1)	(0.4)	3.4	3.5
56.0	2.0	3	1.9	1.2	3.6	1.4	13.2
57.0	2.0	3	(14.6)	11.8	4.8	4.4	2.6
58.0	2.0	3	14.7	(6.7)	-	7.3	7.8

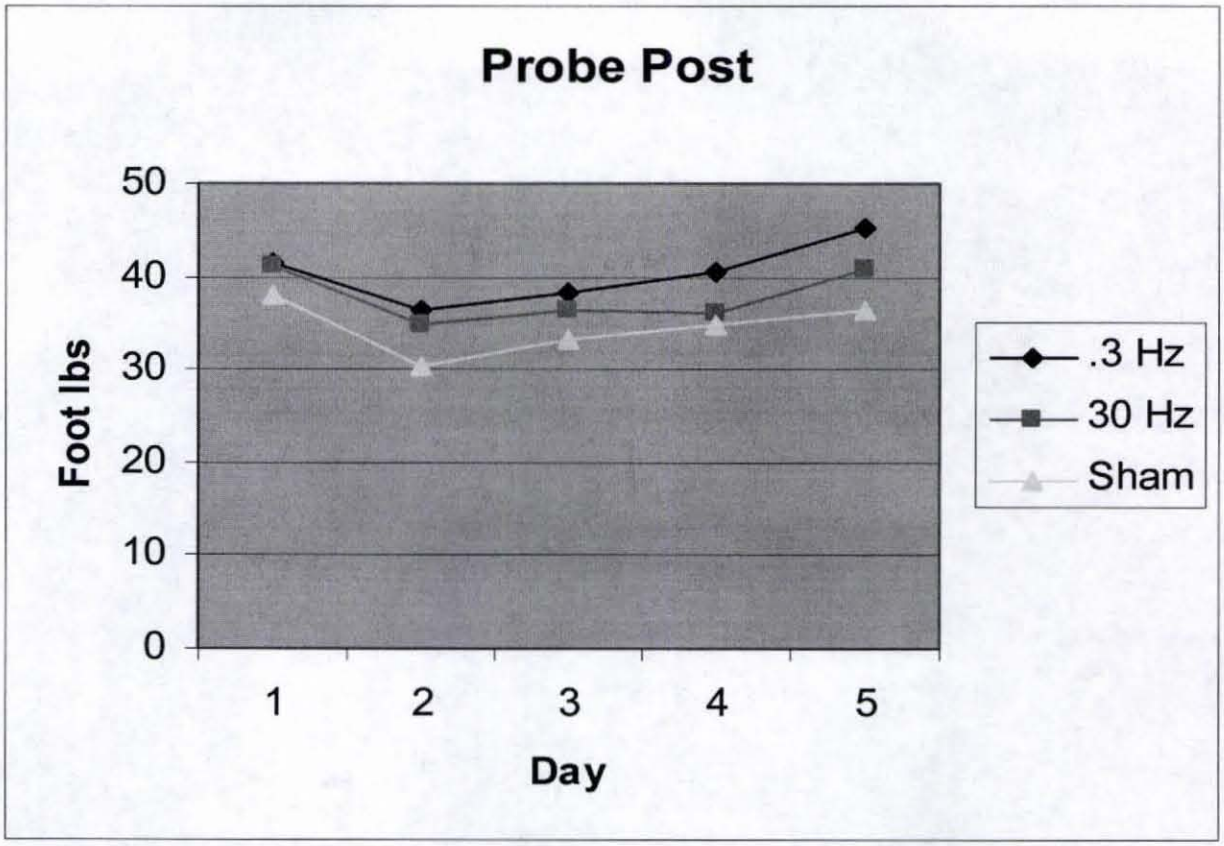
APPENDIX D

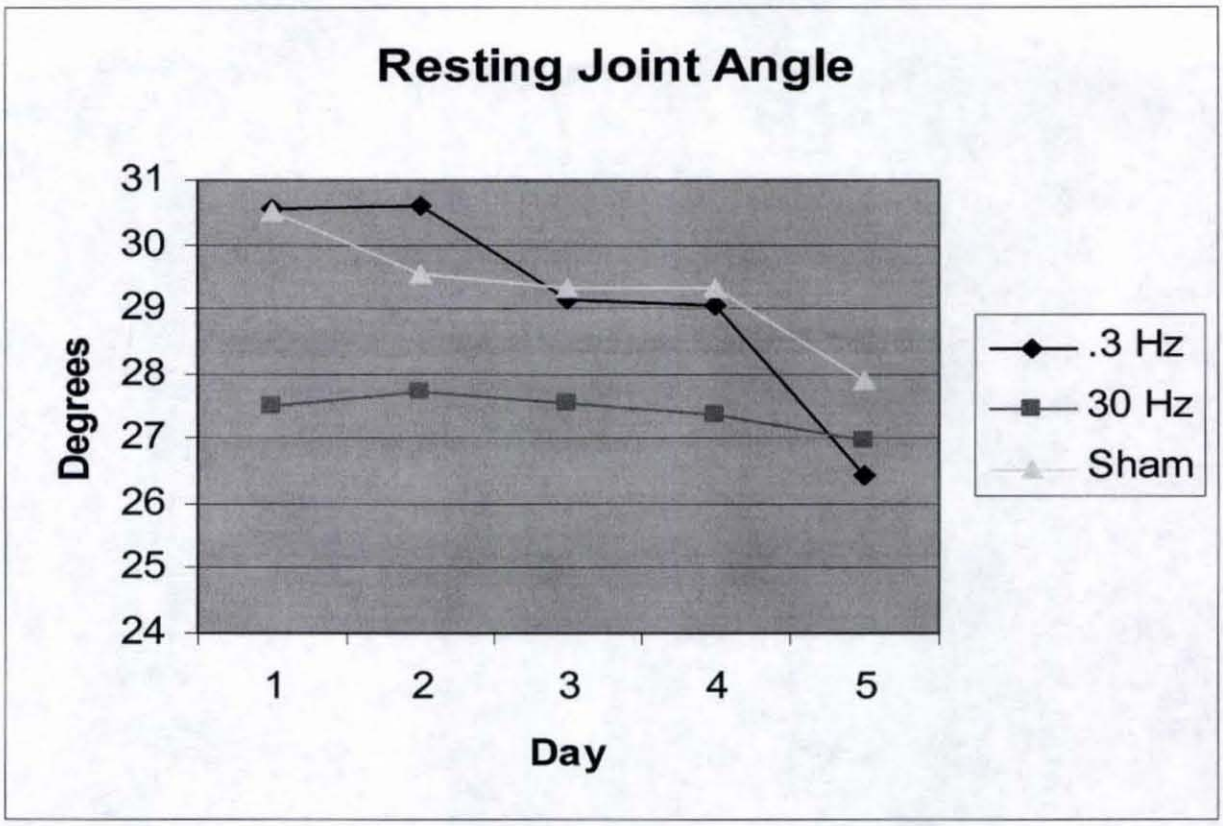
Means for Figures ofPerceived Pain, Palpable Tenderness, Circumference 4, 8, and 12 cm, Resting Joint Angle (Biceps Shortening), and Biceps Isometric Force for Post treatment and Delta Data

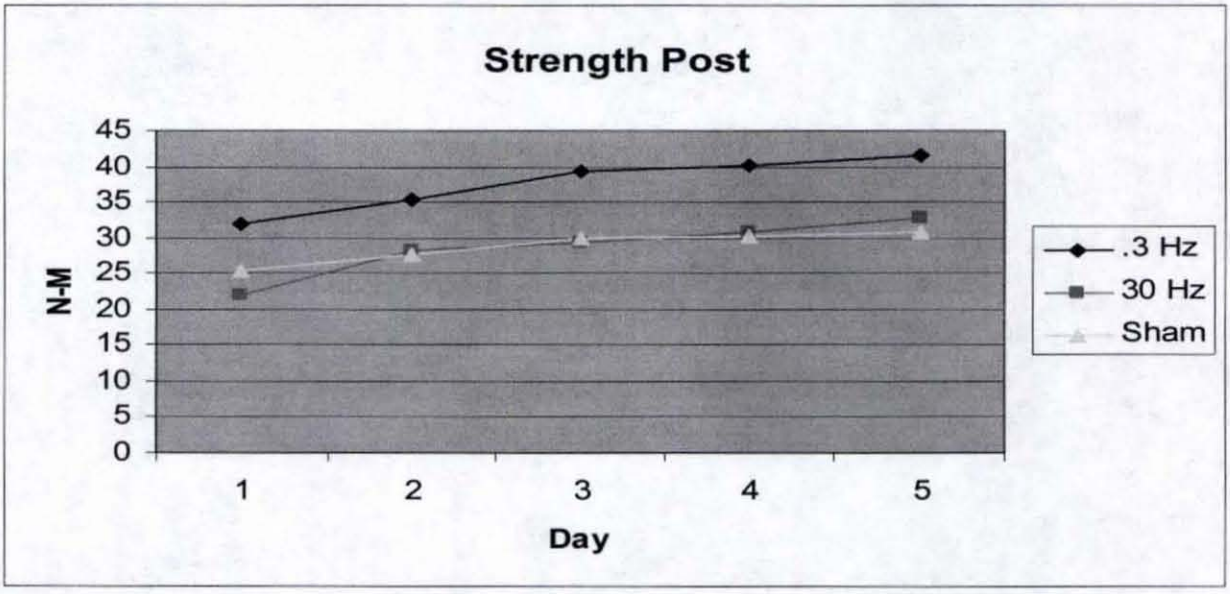

C4 Post
Circumference cm.
26.5
26
25.5
25
24.5
24
1
2
3
4
5
Day
0.3
30
Sham

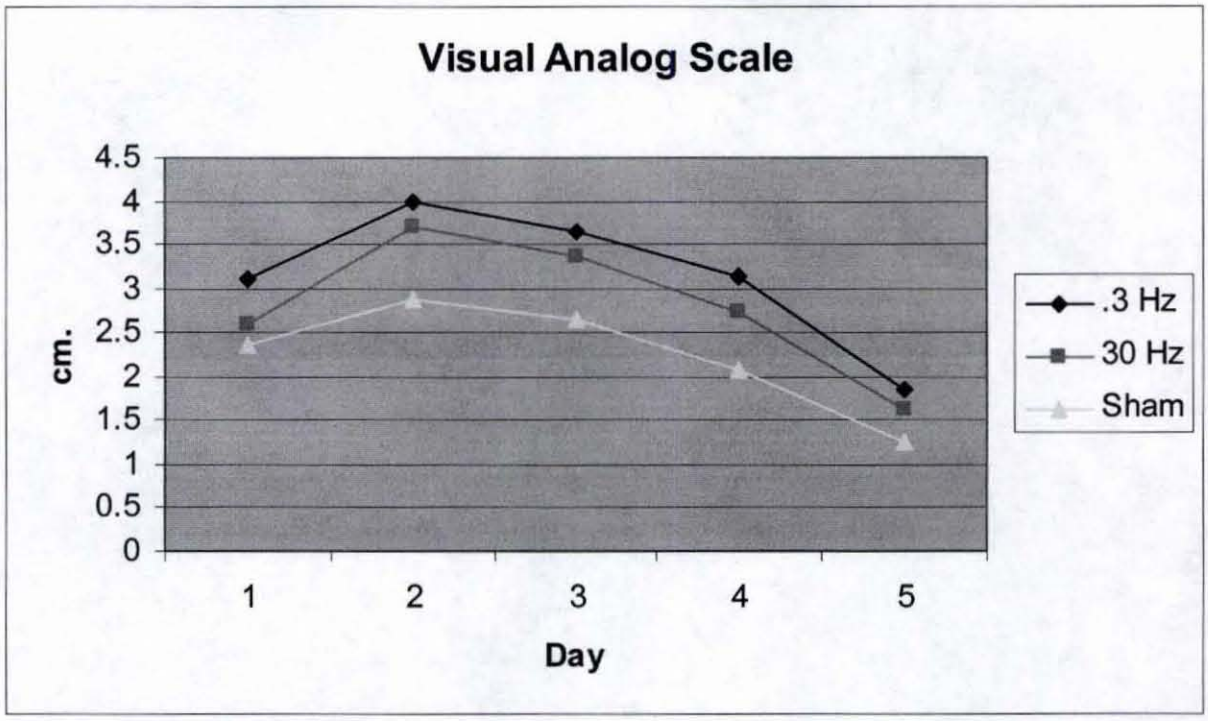

C8 Post
Circumference cm.
29
28.5
28
27.5
27
26.5
26
25.5
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

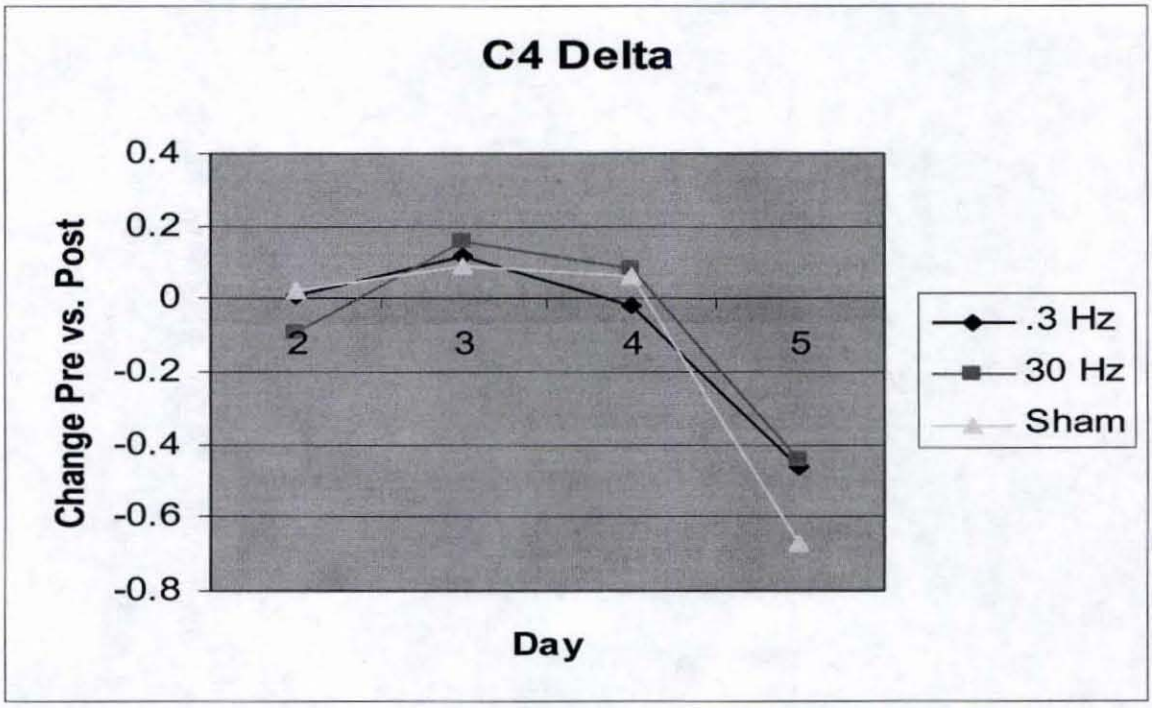

C12 Post
Circumference cm.
30.5
30
29.5
29
28.5
28
27.5
27
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

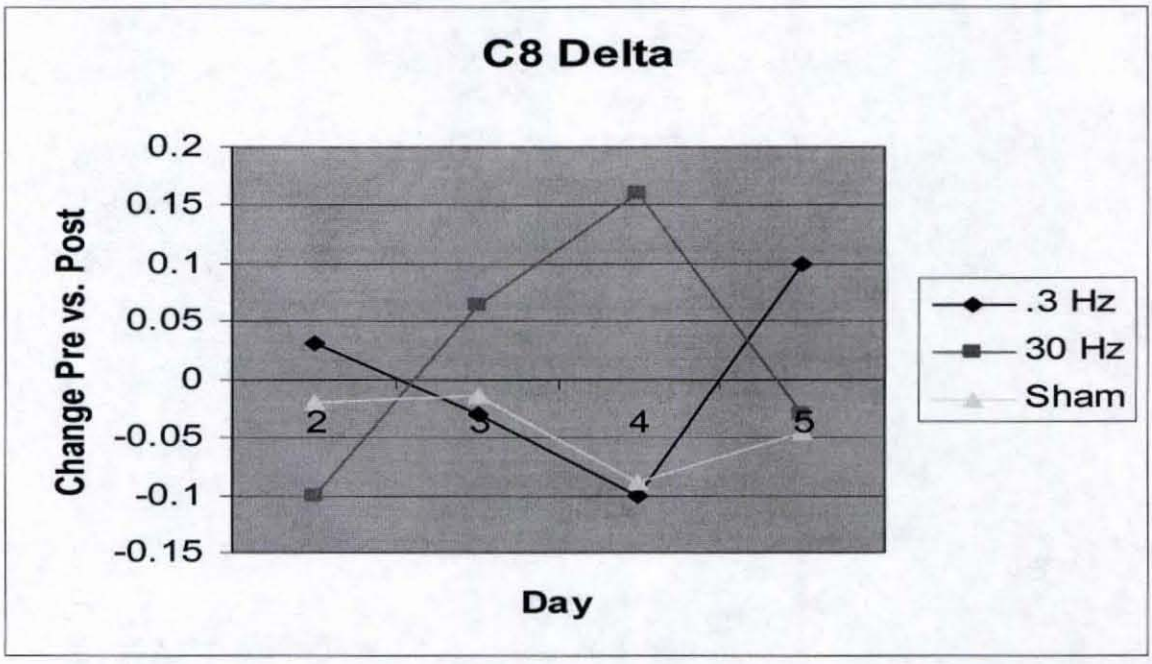

Probe Post
Foot lbs
50
40
30
20
10
0
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

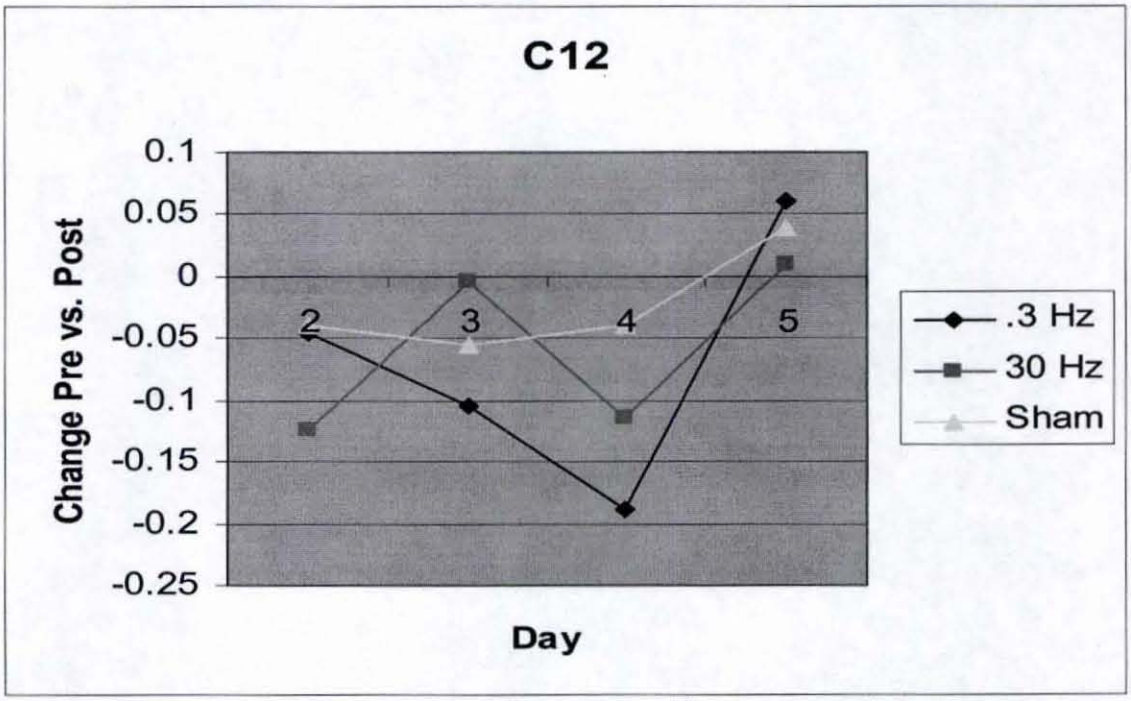

Resting Joint Angle
Degrees
31
30
29
28
27
26
25
24
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

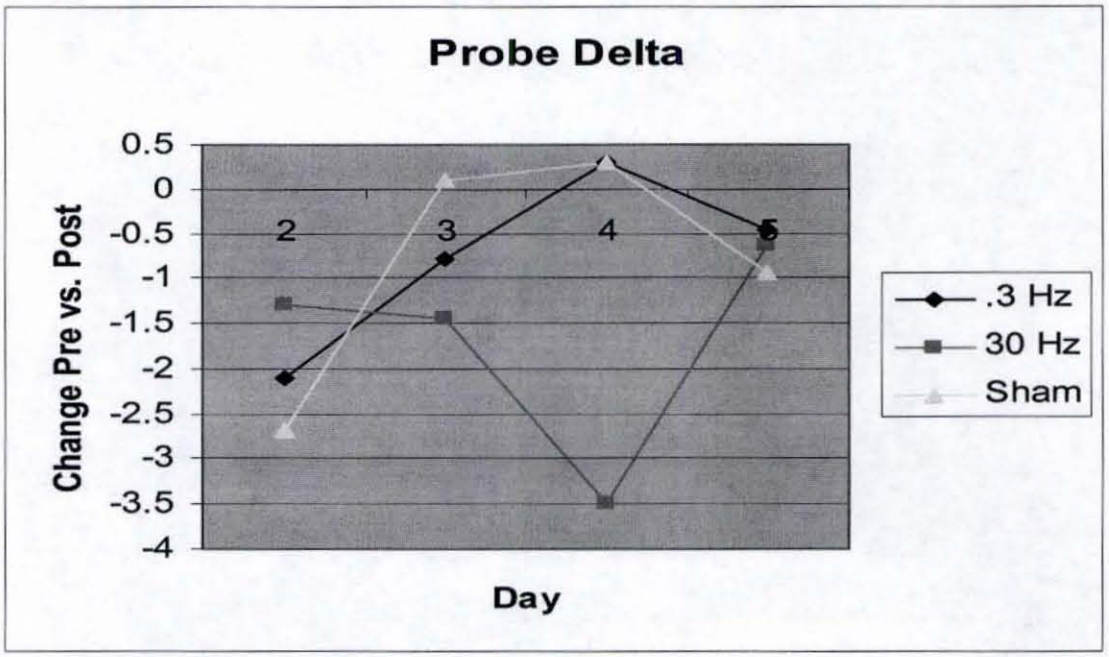

Strength Post
N-M
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

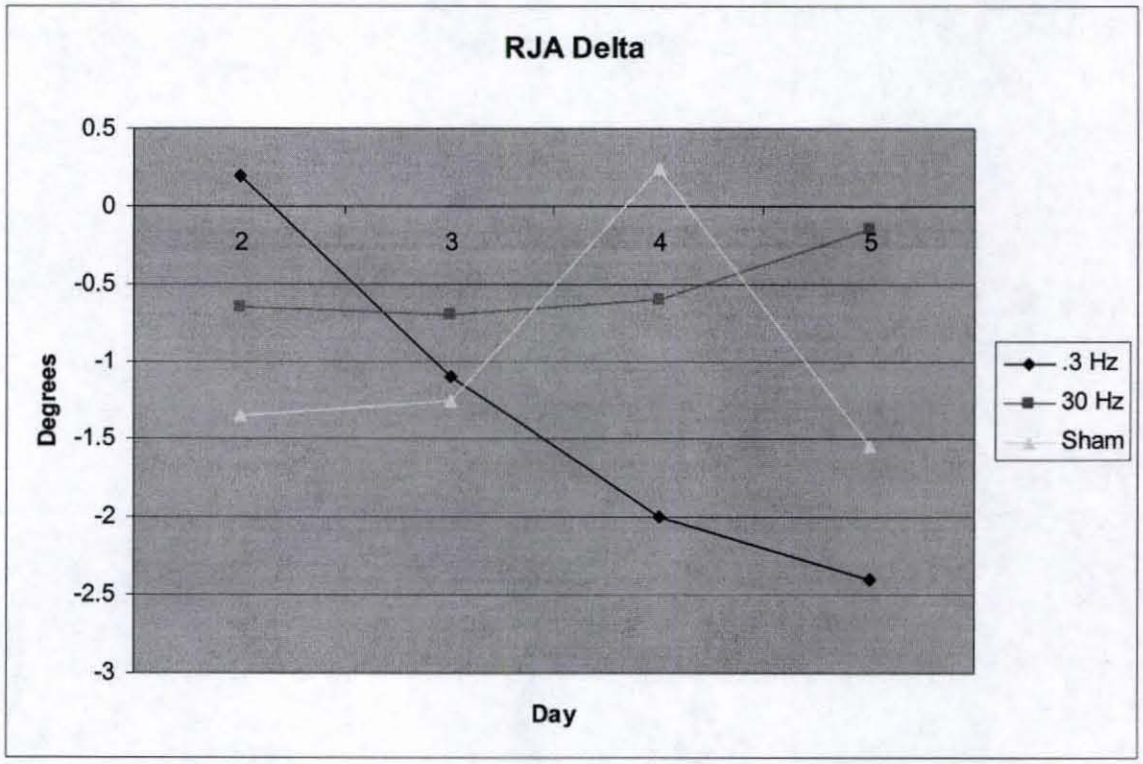

Visual Analog Scale
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
cm.
1
2
3
4
5
Day
.3 Hz
30 Hz
Sham

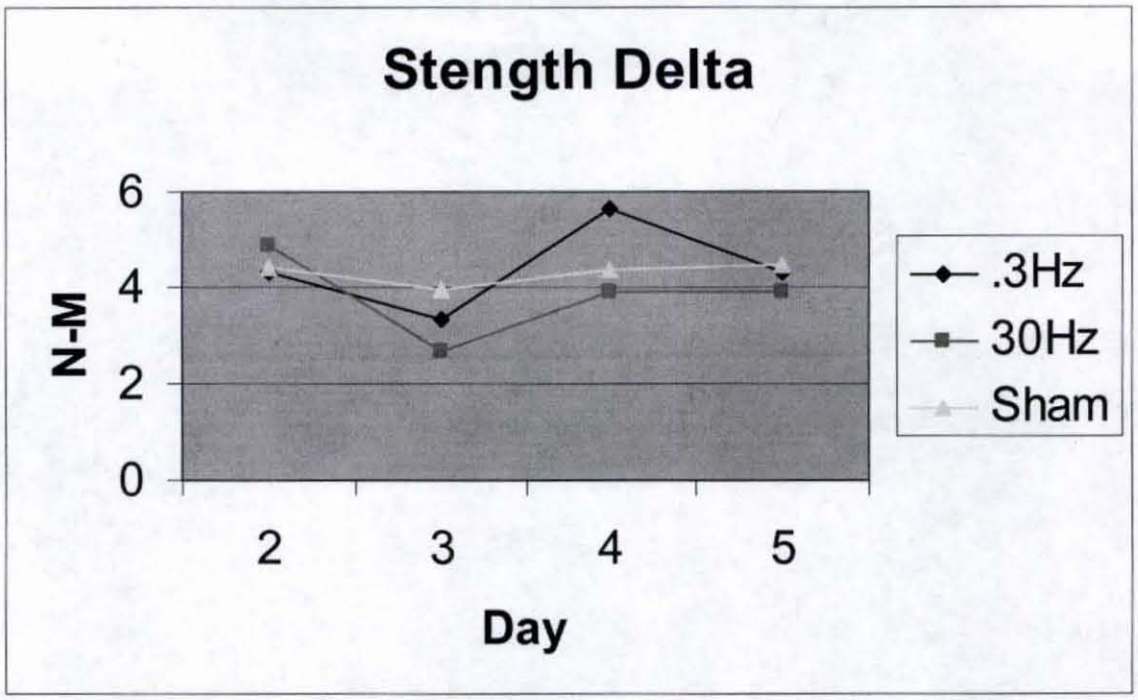

C4 Delta
Change Pre vs. Post
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
2
3
4
5
Day
.3 Hz
30 Hz
Sham

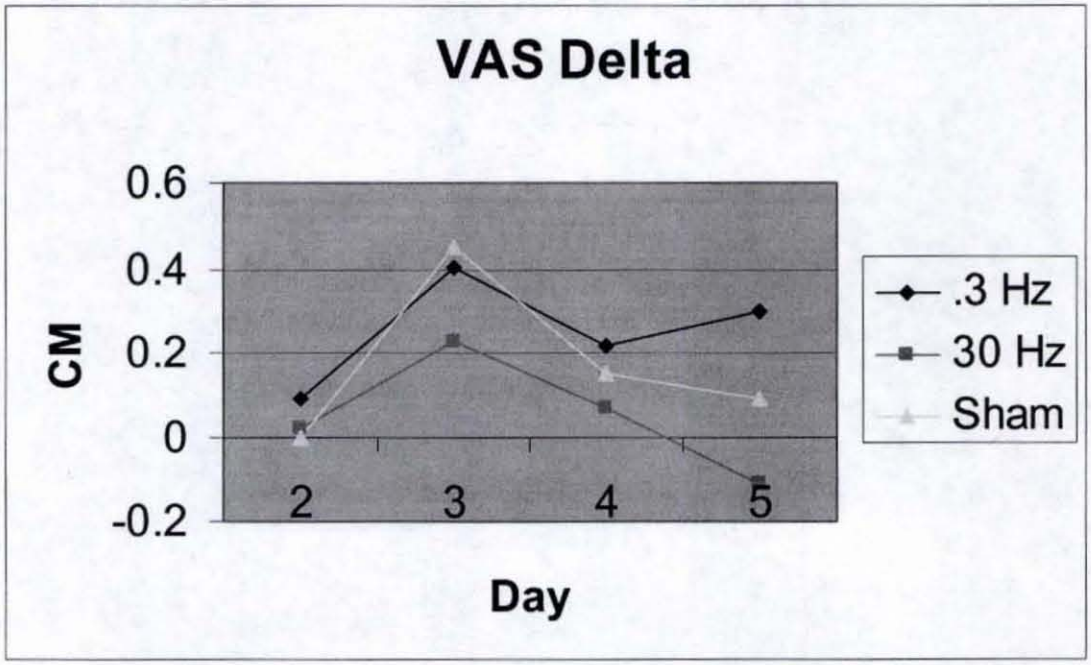

C8 Delta
Change Pre vs. Post
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
2
3
4
5
Day
.3 Hz
30 Hz
Sham


C12
Change Pre vs. Post
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
2
3
4
5
Day
.3 Hz
30 Hz
Sham


Probe Delta
Change Pre vs. Post
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
2
3
4
5
Day
.3 Hz
30 Hz
Sham


RJA Delta
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Degrees
2
3
4
5
Day
.3 Hz
30 Hz
Sham


Stength Delta
N-M
6
4
2
0
2
3
4
5
Day
.3Hz
30Hz
Sham


VAS Delta
CM
0.6
0.4
0.2
0
-0.2
2
3
4
5
Day
.3 Hz
30 Hz
Sham