Laboratory Activities for Therapeutic Modalities

Third Edition

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Prefaces

The modalities included in the exercises in this laboratory manual are intended to be used according to the manufacturers' safety and operating recommendations. Contraindications to the use of these modalities must be ascertained and observed.

Preface to the Third Edition

The goals for this edition remain unchanged from those of the first and second editions: to provide students with hands-on activities that illustrate the concepts underlying the use of therapeutic modalities and to promote problem-solving through application of the discovered material. By using the second edition of this lab manual, we saw a need to reorganize the book into units. Each unit begins with basic background information for and contraindications to use of the various modalities. The order of the activities within a unit is intended to build on principles for the use of modalities of similar types.

As with the first and second editions, this manual is designed as an adjunct to a textbook and is not meant to stand alone. Although we have included lists of contraindications to the use of specific modalities at the beginning of each unit, the responsibility to ensure that the activities are conducted safely lies with the instructor.

This edition features a reorganization of the class activities into units to assist students in obtaining concepts of related modalities and treatments in a logical order. The laboratory activities can be conveniently modified by the instructor to incorporate available equipment and different content sequences. We have added more activities, modified others, and updated the questions. Additionally, we moved information presented in the appendices into appropriate units to enhance the concepts being presented within the activity. Lastly, we placed case studies at the end of each unit, thus enhancing practical application of modalities. Students are encouraged to compare and contrast treatments that would be applicable for setting up treatments related to the case studies.

MaryBeth Horodyski
Chad Starkey

Preface to the Second Edition

Our experience with the first edition of this laboratory manual indicates that students are better able to explain concepts after actually experiencing them. Our goals remain the same with this edition: to provide students with hands-on activities that illustrate the concepts underlying the use of therapeutic modalities and to promote problem-solving through application of the discovered material.

As with the first edition, this manual is designed as an adjunct to a textbook and is not meant to stand alone. Although we have included a list of contraindications to the use of specific modalities in Appendix 1, the responsibility to ensure that the activities are conducted safely lies with the instructor.

This edition continues to feature a series of well-structured laboratory activities that can be modified by the instructor to incorporate available equipment and different content sequences. We have added some activities, modified others, and updated the questions and answers following each to reflect the most current research findings.

We have also added a Universal Skill Assessment Instrument (following the case studies) that allows evaluation of the actual modality application. This tool can be used in conjunction with the case studies or as a student is practicing actual modality application.

Sara D. Brown
Chad Starkey

Preface to the First Edition

After many combined years between us of teaching therapeutic modalities, we found a need for structured laboratory activities beyond the rote setup and application of the equipment. Too often students were becoming technicians rather than clinicians. We also found a secondary need to expose the student to the physical sensations and the physiological effects of the energy delivered by therapeutic modalities, reinforcing the didactic segment of our courses. This manual represents our combined efforts to improve the students' laboratory experience with therapeutic modalities.

This laboratory manual is designed to be an adjunctive tool for most of the existing textbooks on therapeutic modalities and should not be considered a stand-alone text on this topic. While we have included contraindications for each of the modalities used (Appendix I), the ultimate responsibility for the safe setup and application rests with the students and their instructors.

While structured procedures are described for each of the activities, they may be modified by the instructor to make use of the available equipment and fit the educational level of the students. Depending on the experience of the student, this laboratory manual provides avenues for incorporating therapeutic exercise into many of the activities, exercises, and case studies. The quasi-experimental design of the activities allows the integration of statistical analysis. Before the beginning of the class, the instructor should refer to Appendix A for an explanation of the equipment used in measuring skin temperature.

Each activity is followed by a series of discussion questions. A brief explanation and rationale for the correct response appears in Appendix E. Perforated pages are provided so that the results of the class activities and exercises can be submitted at the instructor's request.

Copies of the grids for each activity are provided in Appendix H. The intent of these grids is to allow the student to repeat an exercise. Please avoid the temptation to copy these for mass distribution.

The manual concludes with a series of case studies. After much deliberation we decided to include only a list of the problems that should be surmised from each case (Appendix G). The wide range of methodologies and ideologies surrounding treatment options made even an effort to create a "correct" response dubious at best.

Chad Starkey
Sara D. Brown

Contents

UNIT 4

Electrical Stimulation Modalities

Background and Discussion

The use of electrical stimulation incorporates a wide variety of application techniques. Electrical stimulators are becoming increasingly sophisticated, with single machines frequently capable of generating several currents. Many find this intimidating; however, the fundamentals remain the same. Knowledge of these fundamentals enables the practitioner to become familiar quickly with the capabilities of any unit (regardless of how it is packaged) and underscores the fact that a single current type can be manipulated to provide a wide range of effects. One patient's perceptions of the relative comfort of a specific parameter may differ dramatically from those of another patient. Some parameters (e.g., frequency) must be set in a specified range to achieve a specific therapeutic effect. Other parameters (e.g., shape of the wave) can be adjusted according to personal preference without negatively influencing desired treatment effects.[12]

Some protocols call for sensory-level stimulation only, whereas others use an electrically induced muscle contraction. Occasionally, even a noxious (painful) stimulus is desired. Each of these sensations results from the response of a particular type of nerve. Whether a nerve fires in response to electrical stimulation is determined by the nerve's diameter and depth and by the pulse duration and intensity of the stimulation.

The larger the diameter of the nerve, the lower its resistance and the lower the amplitude necessary for its stimulation. Logically, deeper nerves require a greater amplitude for stimulation than more superficial nerves. In normal, innervated tissue, the order in which nerves are stimulated is constant. As the intensity is increased, sensory fibers are stimulated first, followed by motor nerves and then pain fibers. If the intensity is increased past the point of pain, muscle fibers are then directly stimulated. Short pulse durations allow for the greatest selectivity in the stimulation of these fibers. As the pulse duration is increased, the amount of selectivity between the individual fibers is decreased.

An electrical current travels through the body by forming a sequence of parallel circuits, opting for the path of least resistance. Changing the configuration of the electrode placement alters the path of the current, although the area of greatest current density remains directly under the electrode(s) with the smallest surface area. Little or no stimulation is detected under the dispersive electrode when a monopolar configuration is used because the surface area of the dispersive electrode is greater than the surface area of the treatment pads. The depth of the treatment effect corresponds to the proximity of the electrodes, with the depth increasing as the space between the electrodes increases. When the subject shifts off the dispersive electrode during treatment or the conducting medium dries out, a greater current density occurs along this diminished pathway. The perceived sensation increases, sometimes painfully so. For this reason, gel or gel-impregnated electrodes are often used as a coupling agent instead of water when electrical stimulation is applied over a long period. The gels are less apt to dry out and therefore deliver current at a constant density.

The DC generator (e.g., Iontophoresor) creates a continuous electromotive field between the anode and cathode. This allows for migration of hydrogen toward the cathode and oxygen to the anode. These lines of force between the poles of a monophasic generator are less distinct because of the interruption in the current flow. During the periods of noncurrent flow, the ions are capable of drifting freely in any direction, ultimately reducing the net migration of the ions. Direct evidence of the effects of stimulation using a galvanic current occurs when burns result from build-up of acid or alkaline by-products.[16] Because of this risk, only low amplitude and short durations are used with this current type. Decreasing skin impedance through procedures such as shaving and warming also helps reduce these undesirable side effects.

When using electrical stimulation to elicit a muscular contraction, the placement of the electrodes greatly influences the amount of current necessary to elicit a contraction. Placing the electrodes directly over motor points produces a maximum motor response using a minimum of current. If the current density over the muscle or muscle group is kept high, more motor points (and therefore motor units) will be recruited into the contraction. Increasing the output intensity by stimulating motor nerves in adjacent areas also has the same effect.

In theory, the polarity used (when a choice is possible) can also affect the motor response. According to Pflueger's law, less current is required to depolarize a nerve at the cathode (negative pole) than at the anode.[13] Of course, this is only meaningful when a direct or monophasic current is used.

Motor points, however, are not the only areas of decreased electrical resistance. Acupuncture points and trigger points also demonstrate diminished surface electrical resistance. Located on meridians, acupuncture points, theoretically, are entrances into different energy systems of the body. Trigger points, motor points, and acupuncture points are often painful to palpation in the presence of injury.

Almost any type of electrotherapeutic modality can elicit a muscle contraction in normal, healthy muscle. All that is needed is sufficient intensity to depolarize the motor nerve's membrane. Certain forms of electrical stimulation may depolarize the motor nerve's membrane more easily and with greater comfort. While electrical stimulation is capable of producing involuntary muscle contractions, combining electrical stimulation with volitional muscle contraction can produce contractions that exceed the maximal voluntary isometric contraction.

It should be noted that the overall strength of a muscle is affected more through voluntary muscle contractions than through electrically induced muscle contractions. Electrical stimulation produces less desirable muscle contractions than voluntary contractions but can be used to supplement and augment voluntary contractions. This should drive the clinician to use electrical stimulation not as a replacement for voluntary contractions but as a supplement to voluntary contractions.

When using electrically induced muscle contractions for strength gains, the effect of fatigue must be considered. As with all exercises and muscle contractions, a rest time is needed to allow the muscles to recuperate. Treatment sessions with electrically induced muscle contractions should occur every other day as is typical of normal workouts. Increasing strength is most effective when recruiting the maximal number of muscle fibers. This should be kept in mind when choosing pulse frequencies. Lower frequencies result in twitch contractions, which do not recruit the largest amount of muscle fibers. Higher frequencies result in tetanic or tonic muscle contractions, which recruit larger numbers of muscle fibers.

The types of muscle fibers that are recruited in electrically induced muscle contractions must be kept in mind. Electrical stimulation reverses the order of recruitment of muscle fibers. In voluntary contractions, small-diameter type I motor nerves are first to be recruited. In electrically induced muscle contractions, type II motor nerves are first to be recruited. Type II motor nerves are capable of producing more force but also fatigue quickly, whereas type I fibers are able to sustain lower force contractions for prolonged periods.

Cold application has been thought to decrease pain by decreasing the excitability of the pain-causing free nerve endings, stimulating large-diameter neurons, "closing the gate" as described by the gate control theory, and evoking descending inhibition through the central biasing mechanism. Cold modalities are frequently used for a temporary reduction of pain to enhance the subsequent treatment. For example, cold might be used before or during potentially painful active range-of-motion exercises in a technique known as cryokinetics. Additionally, pain caused by the stimulating current determines the upper limits of torque production.

Research studies have been conducted to determine if cold application prior to electrical stimulation alters the torque produced by an electrically evoked muscle contraction. One study using ice massage as the method for delivering cold found a significant increase in torque production among subjects receiving such treatment compared with those receiving no such treatment.[14] A similar study using ice bags found no significant difference between the two groups.[15]

Contraindications

General

- Cardiac disability
- Exposed metal implants, such as those used for external fixation
- Severe obesity
- Over areas of particular sensitivity
- Carotid sinus
- Esophagus (laryngeal or pharyngeal muscles)
- Pharynx
- Mucosal membranes
- During pregnancy
- Skin irritation due to electrode placement

Motor-Level Stimulation

- Unwanted muscle contraction or active movement
- Hemorrhage or active inflammation
- Malignancies

Direct Current (Iontophoresis)

- Anesthetic skin
- Recent scars
- Metal implants
- Exposed metal
- Acute injury
- Cardiac pacemakers
- Contraindications or sensitivity to the medication(s) being used

ACTIVITY 4–1

Ohm's Law

Objective

To demonstrate an understanding of the relationship between voltage, amperage, resistance, and the power of an electrical circuit.

Description of Ohm's Law

Ohm's law is a mathematical equation that describes a relationship in which amperage (I) is directly proportional to voltage (V) and inversely proportional to resistance (R). Expressed as an equation, each variable can be calculated if the other two variables are known. To calculate:

Amperage	Voltage	Resistance
I=V/R	V=IR	R=V/I

The total resistance to current flow is based on the type of electrical circuit involved. In a series circuit where the electrons have only one path to travel, the total resistance is equal to the sum of all the resistors:

$$R_t = r_1 + r_2 + r_3 \ldots$$

In a parallel circuit, where electrons have multiple routes to travel, the total resistance is inversely proportional to the sum of the individual resistors:

$$1/R_t = 1/r_1 + 1/r_2 + 1/r_3$$

The power of a circuit is described in terms of watts and is calculated by the equation:

$$P = VI$$

Definition of Terms

Amperage (I): The rate of electrical current flow as measured by the number of coulombs passing a single point in 1 second. 1 ampere is equal to the movement of one coulomb per second.

Coulomb (Q): Charge produced by 6.25×10^{18} electrons.

Ohm (Ω): Unit of electrical resistance. 1 ohm is the amount of resistance needed to develop 0.24 calories of heat when 1 ampere of current is applied for 1 second.

Voltage (V): The potential for electron flow to occur. 1 volt represents the amount of work required to move 1 coulomb of charge.

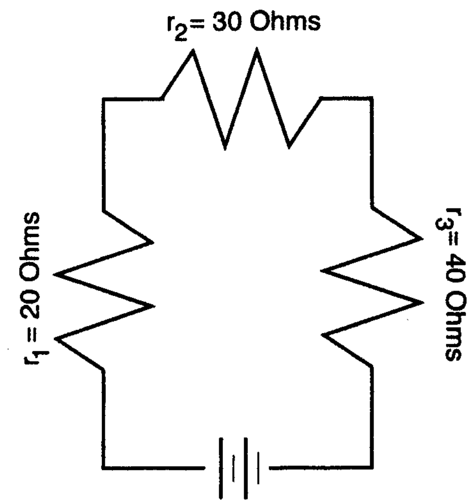
Watt (W): Unit of electrical power that describes the amount of work being performed in a unit of time.

Worksheet 4–1

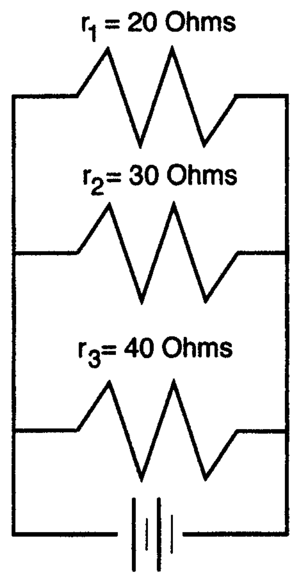
Ohm's Law

Name: ______________________________ Date: ______________________________

Respond to the following questions using the schematics provided below. Show your work.



Series Circuit



Parallel Circuit

1. What is the total resistance in the series circuit? The parallel circuit?

2. Using the resistance value obtained in Question 1, what would be the amperage of each circuit if each is operating at 120 volts?

3. What would the amperage for each of the two circuits be if the voltage were increased to 200 volts?

4. Using the parameters from Question 2, what would the wattage be for each circuit type?

5. Calculate the voltage across each resistor in the series circuit, assuming the circuit is operating at 10 amperes.

6. Calculate the amperage across each resistor in the parallel circuit, assuming it is operating at 100 volts and 10 amperes.

7. Calculate the total resistance in the parallel circuit after adding two additional resistors of 30 ohms each.

8. Using the total resistance value obtained from Question 7, calculate the amperage if the circuit is operating at 120 volts.

9. Compare your answers to Questions 8 and 2 for the amperage of the parallel circuit. After adding resistance, did the amperage increase or decrease? Why?

Selective Stimulation of Nerves

Objective

To understand how adjustment of the pulse duration affects the level of intensity required to stimulate sensory, motor, and pain nerve fibers.

Materials Needed

- Electrical stimulation unit with an adjustable pulse duration (TENS or neuromuscular electrical stimulation recommended). Units with a digital output display produce the most objective results.

Procedures

1. Depending on the stimulating unit used, select either a monopolar or bipolar electrode configuration. When using a monopolar electrode configuration, attach the "dispersive" electrode on the subject's lower back or thigh and the "active" electrode to the anterior portion of the subject's forearm. (This configuration is recommended for high-volt pulsed units). If other stimulators are used, arrange the electrodes in a bipolar configuration, placing one electrode on the distal portion of the subject's forearm and the other on the proximal portion of the forearm (Fig. 4–1).
2. Set the stimulation parameters to the following values:

Parameters	**Settings**
Pulse duration:	25 µsec (or lowest possible value)
Pulse frequency:	30 pps
Pad alternating rate:	Continuous
Modulation parameters:	Off (constant output)
Duty cycle:	100%
Polarity:	Positive

   Note: Not all parameters will apply to each unit.
3. Position the stimulation unit so that the subject cannot see the intensity reading.
4. Slowly increase the intensity to the level where the subject first reports the sensation of electrical current flow. Record the output intensity on the grid provided.
5. Further increase the intensity until a visible muscle contraction can be seen, and record the output intensity.
6. Continue to increase the intensity until the subject reports discomfort resulting from the stimulation. Reduce the intensity to zero, and record the output intensity
7. Allow the subject recovery time from the stimulation bout.
8. Repeat Steps 3 through 7 using increased pulse durations (e.g., 10 µsec, 20 µsec, 40 µsec, 80 µsec, and 160 µsec).
9. Conclude this activity using the original pulse duration.
10. Using the labeling key provided, plot the changes in the output intensity required to stimulate sensory nerves, motor nerves, and pain nerves between the various pulse durations.

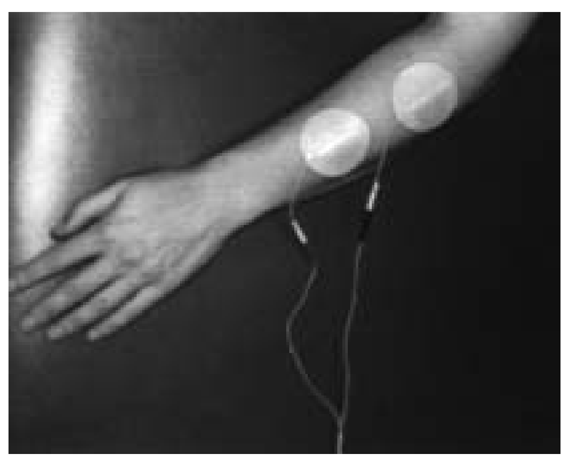


Figure 4–1. Placement of electrodes.

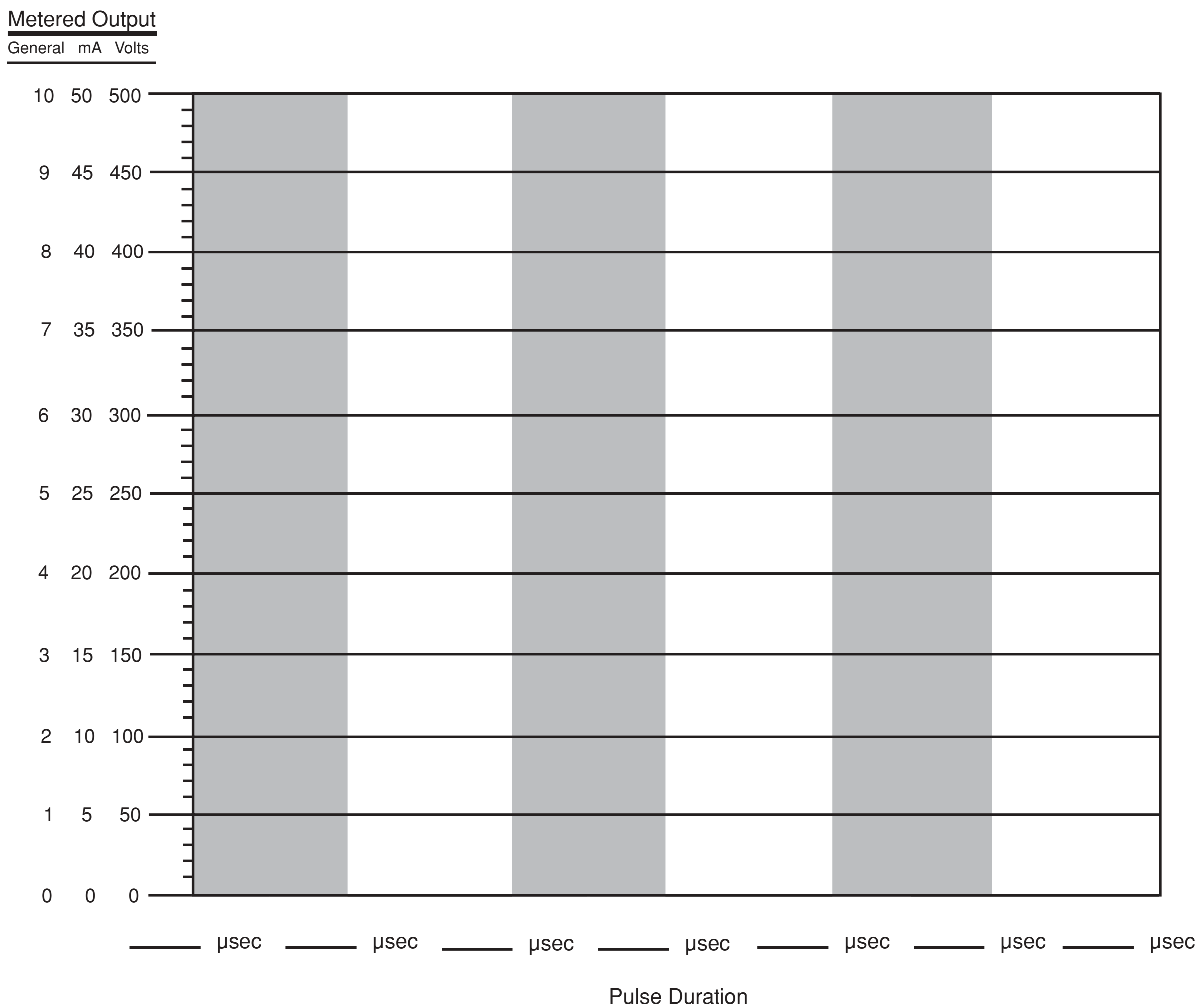
Worksheet 4–2

Selective Stimulation of Nerves

Name: ______________________ Date: ______________________

Subject(s): ______________________

Type of Stimulation Unit Used: ______________________



Labeling Key	
○ Sensory Nerves	□ Pain Nerves
● Motor Nerves	

Activity Questions

1. Was the interval between sensory, motor, and pain stimulation reduced as the pulse duration was increased? Based on these results, what can you infer about the comfort level of an uninterrupted direct current (galvanic)?

2. Based on your results, what would be the optimal pulse duration if your treatment goal was to achieve maximal sensory stimulation without muscle contraction?

3. Note that the electrode-skin interface will affect resistance. Does the actual amplitude reading have any clinical relevance? Why or why not?

4. Compare the two first and last readings using the same shortest pulse duration. Were they the same? To what do you attribute any difference?

ACTIVITY 4–3

Pulse Characteristics

Objective

To demonstrate knowledge of the characteristics associated with therapeutic currents.

Electrical Stimulating Currents

Direct Current: The uninterrupted unidirectional flow of electrons.

Alternating Current: The uninterrupted bidirectional flow of electrons.

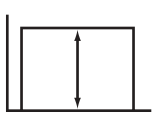
Pulsed Current: The flow of electrons interrupted by discrete periods of noncurrent flow.

Monophasic Current: A unidirectional pulsed current.

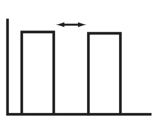
Biphasic Current: A pulsed current possessing two phases, each of which occurs on opposite sides of the baseline.

Definition of Pulse Characteristics

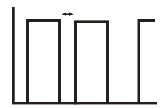
Amplitude: The maximal distance that a pulse rises above or below the baseline.



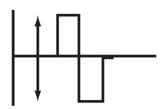
Interpulse Interval: The period of time between pulses during which there is no current flow.



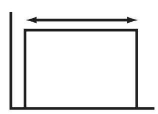
Intrapulse Interval: The period of time within a single pulse during which there is no current flow. The duration of the intrapulse interval cannot exceed the duration of the interpulse interval.



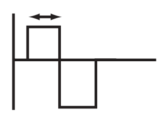
Peak-to-Peak Amplitude: The absolute value measured from the maximal rise on the positive side of the baseline to the peak on the negative side.



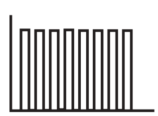
Pulse Duration: The period of time a pulse remains above or below the baseline, normally measured in microseconds.



Phase Duration: The period of time a phase remains above or below the baseline, normally measured in microseconds.

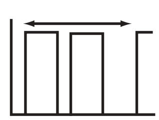


Pulse Frequency: With pulsed currents, this figure represents the number of pulses per second (pps); alternating currents are measured by the number of cycles per second (cps or hertz).



One Second

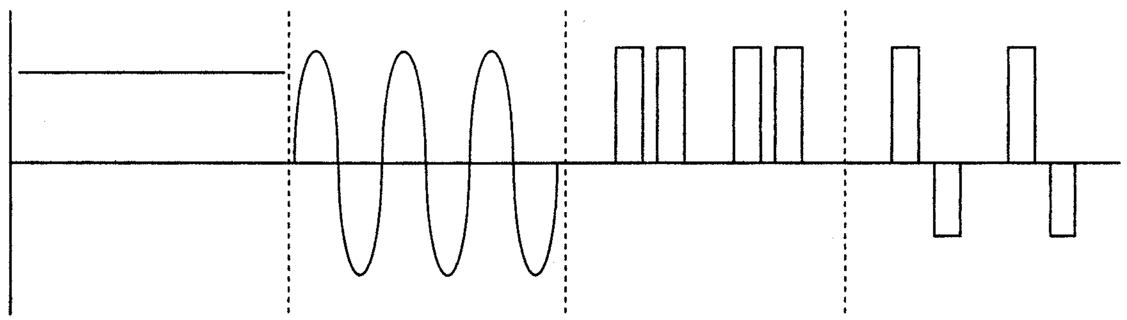
Pulse Period: The period of time between the initiation of one pulse to the initiation of the subsequent pulse.



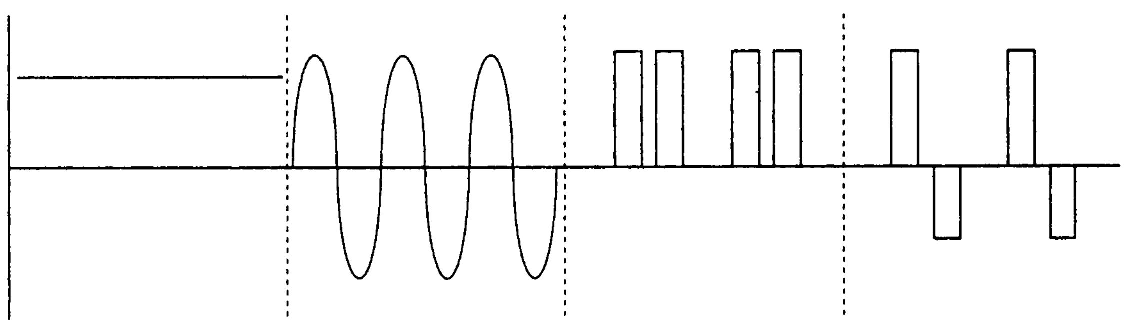
Pulse Characteristics

Name: ______________________ Date: ______________________

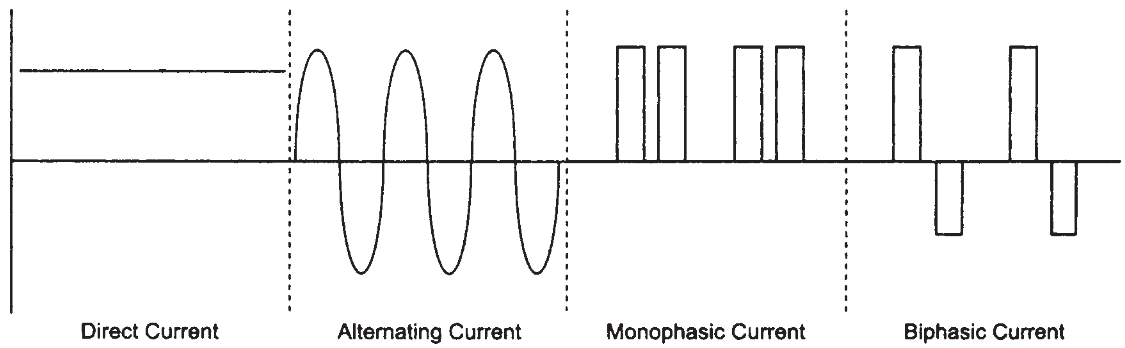
1. Label each of the following current types, indicating the specified parameter. If a particular parameter is not applicable to a particular current, leave it blank.
   A. Identify the amplitude for each of the following currents:



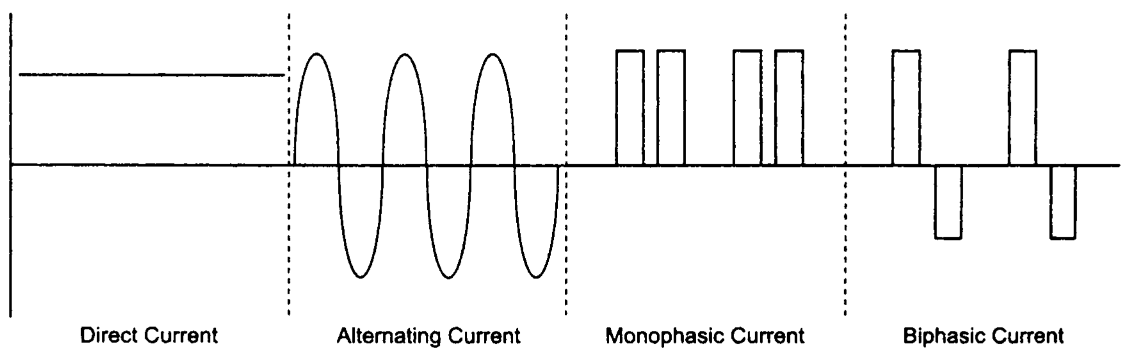
   B. Identify the peak-to-peak value for each of the following currents:



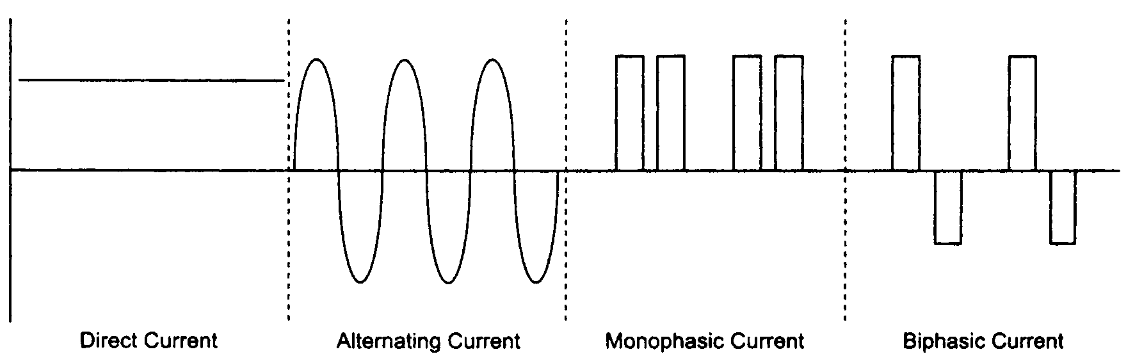
C. Identify the pulse duration for each of the following currents:



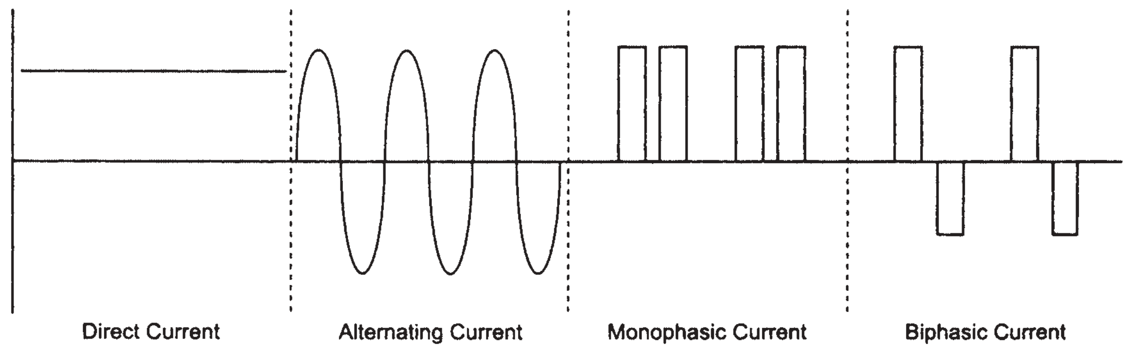
D. Identify the phase duration for each of the following currents:



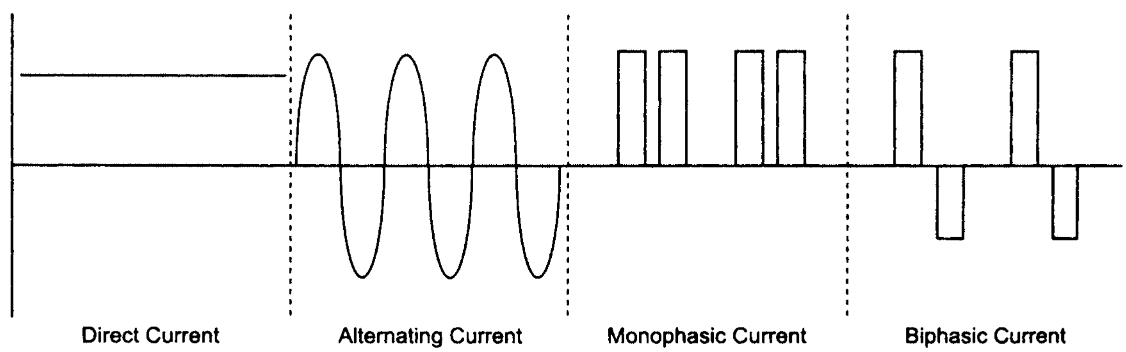
E. Identify the pulse period for each of the following currents:



F. Identify the interpulse interval for each of the following currents:



G. Identify the intrapulse interval for each of the following currents.



2. Calculate the total amount of time electrons are actually moving during a 1-minute period in a pulsed current having a pulse duration of 140 μsec and a frequency of 125 pps. Show your work.

3. The amount of energy delivered to the tissue is represented by the area within a pulse. What two variables can we manipulate to increase or decrease this energy?

Identification of Motor Points

Objective

To be able to locate and identify motor points for specific muscles.

Materials Needed

- Electrical stimulation unit with a hand-held applicator (high-volt pulsed stimulator recommended)

Description of Motor Points

Motor points are superficial areas on the skin that have decreased resistance to electrical current flow. Stimulation of these sites causes large motor nerves to depolarize and therefore isolates the contraction to a single muscle or portion of a muscle. The exact locations of motor points tend to vary from individual to individual, but their approximate locations have been identified in many motor point charts. Motor points are not to be confused with trigger points, which are hypersensitive areas that develop secondary to trauma (although they do frequently tend to be found close to each other).

Procedures

1. Attach the dispersive electrode to the subject's thigh or upper arm, depending on the area being examined, and configure the stimulation unit to the hand-held applicator mode. On units not having a provision for a hand-held probe, a small (e.g., 2-inch × 2-inch) electrode can be used. In this case, attach the dispersive electrode to the subject's thigh or upper arm, and manually move the electrode with one hand while controlling the output intensity with the other.
2. Set the stimulation parameters to the following values:

Parameters	**Settings**
Pulse duration:	25 to 50 μsec
Pulse frequency:	50 pps
Pad alternating rate:	Continuous
Modulation parameters:	Off (constant output)
Polarity of the active electrode:	Negative
Duty cycle:	100%

Note: Not all parameters will apply to each unit.

3. Reset the generator's output intensity to zero, and wet the applicator's tip with water or gel.
4. Place the applicator tip on the subject's forearm, and slowly increase the intensity to where a slight muscle contraction is visible (Fig. 4–4).

Figure 4–4. Use of hand-held applicator.

5. Use the applicator tip to identify the point(s) on the skin that result in strong, isolated contractions of the following muscles:

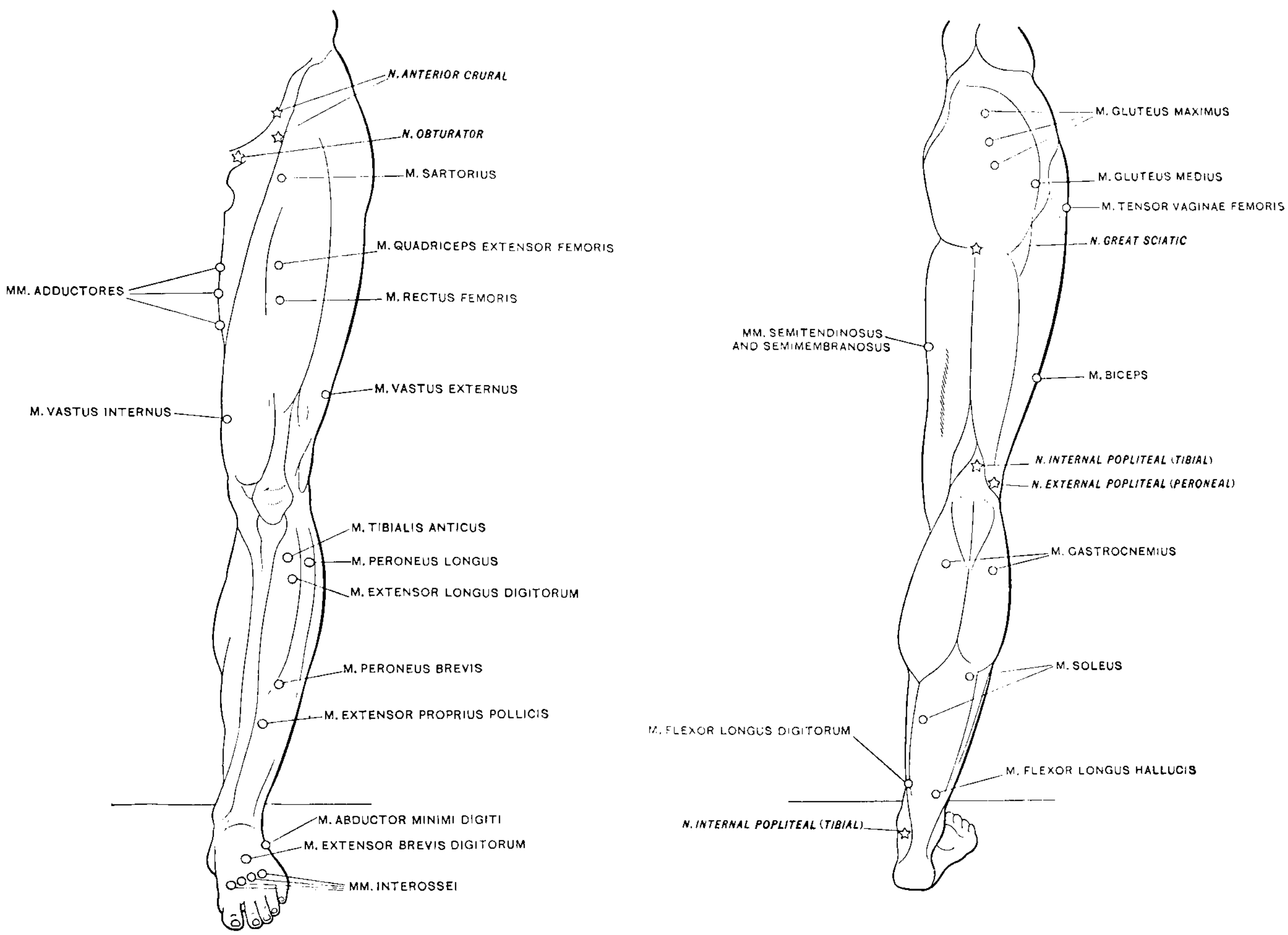
Upper Extremity	*Lower Extremity*
Abductor pollicis longus	Abductor digiti minimi
Extensor digiti minimi	Extensor hallucis longus
Extensor indicis	Extensor digitorum brevis
Flexor carpi radialis	Plantaris
Flexor carpi ulnaris	Tibialis anterior

6. The intensity of the stimulation may need to be adjusted as the applicator is moved over the skin. Most applicators have an intensity adjustment knob located on them. *Note:* Reduce the intensity to zero before applying or removing the applicator from the subject's skin.
7. Using the labeling key, mark the location of each motor point identified on the accompanying charts.

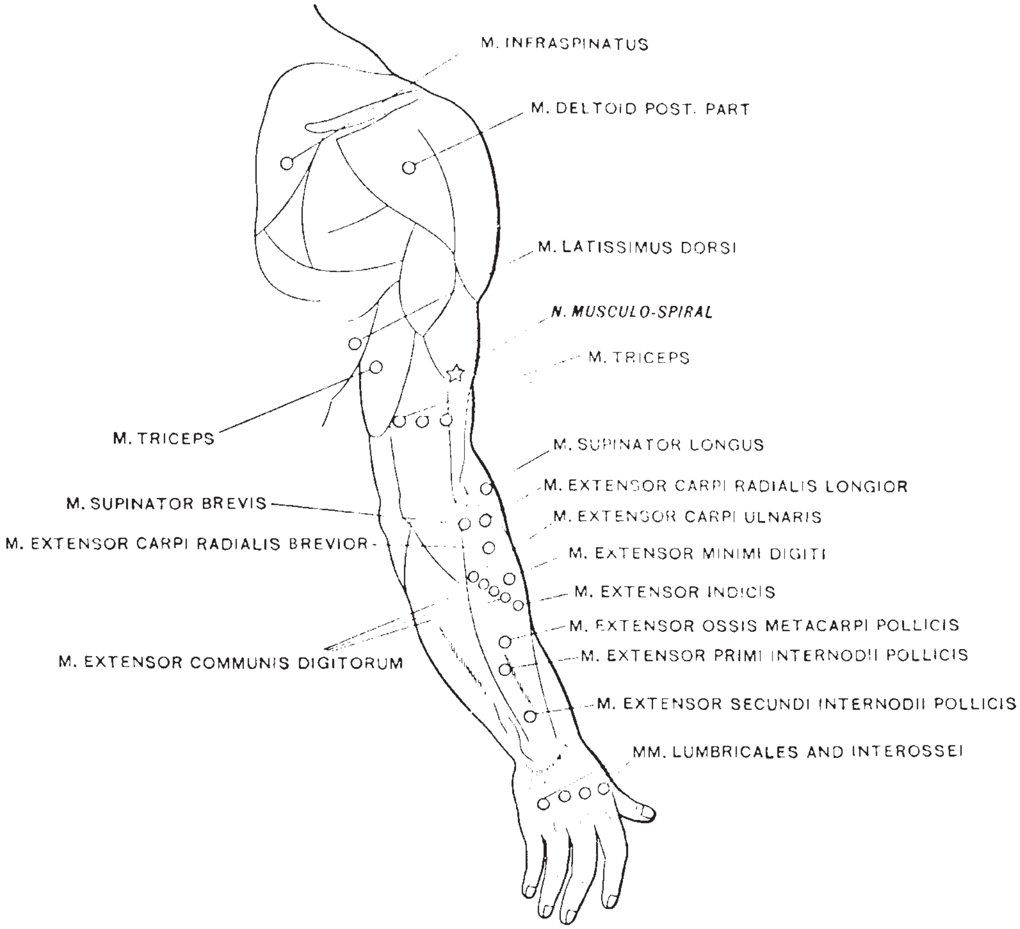
Identification of Motor Points

Name: ______________________ Date: ______________________

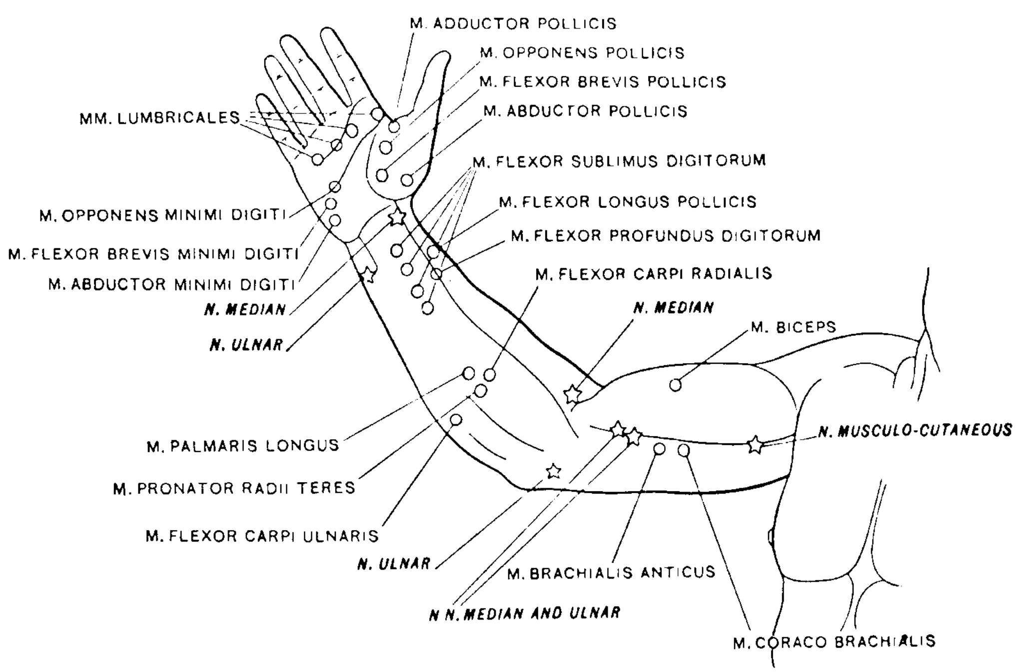
Subject(s): ______________________



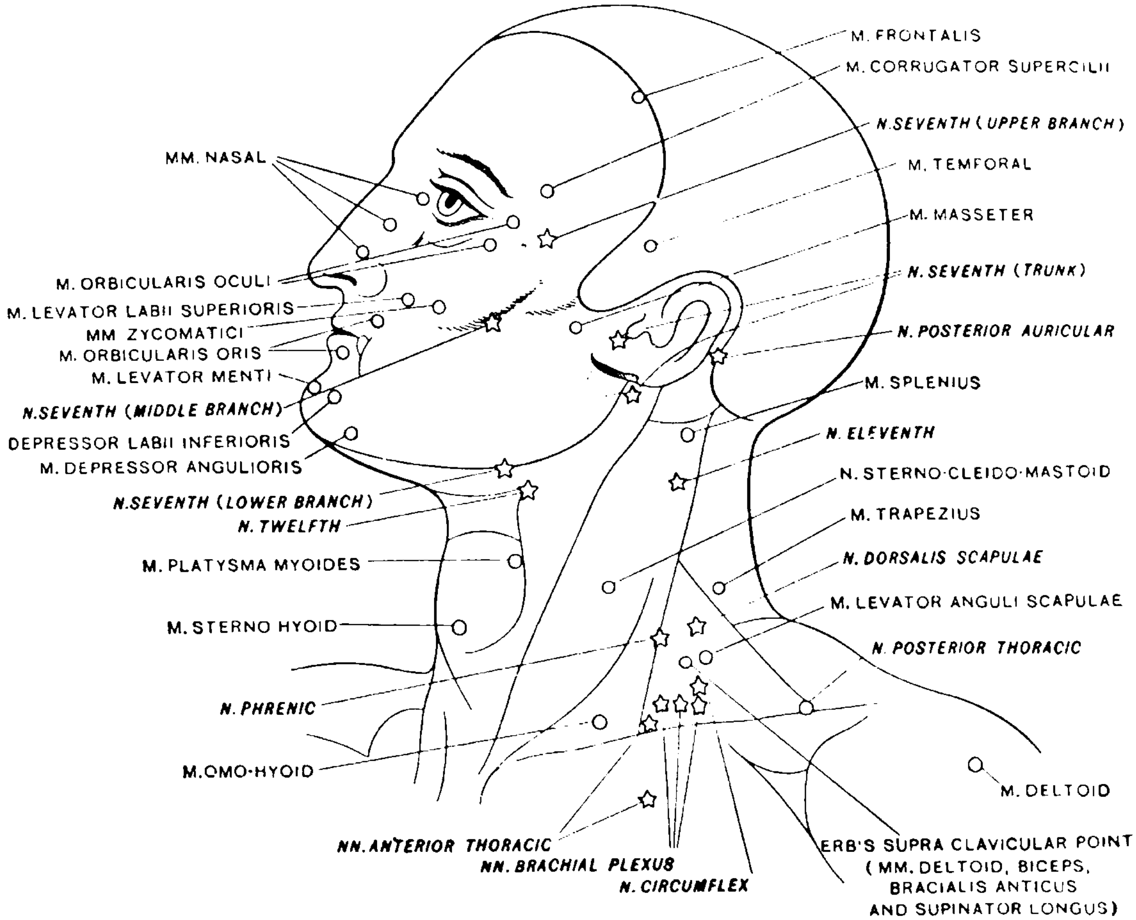
M = Muscle
N = Nerves



M. INFRASPINATUS
M. DELTOID POST. PART
M. LATISSIMUS DORSI
N. MUSCULO-SPIRAL
M. TRICEPS
M. TRICEPS
M. SUPINATOR LONGUS
M. EXTENSOR CARPI RADIALIS LONGIOR
M. SUPINATOR BREVIS
M. EXTENSOR CARPI ULNARIS
M. EXTENSOR CARPI RADIALIS BREVIOR
M. EXTENSOR MINIMI DIGITI
M. EXTENSOR INDICIS
M. EXTENSOR OSSIS METACARPI POLLICIS
M. EXTENSOR PRIMI INTERNODII POLLICIS
M. EXTENSOR COMMUNIS DIGITORUM
M. EXTENSOR SECUNDI INTERNODII POLLICIS
MM. LUMBRICALES AND INTEROSSEI



M. ADDUCTOR POLLICIS
M. OPPONENS POLLICIS
M. FLEXOR BREVIS POLLICIS
MM. LUMBRICALES
M. ABDUCTOR POLLICIS
M. FLEXOR SUBLIMUS DIGITORUM
M. FLEXOR LONGUS POLLICIS
M. OPPONENS MINIMI DIGITI
M. FLEXOR PROFUNDUS DIGITORUM
M. FLEXOR BREVIS MINIMI DIGITI
M. FLEXOR CARPI RADIALIS
M. ABDUCTOR MINIMI DIGITI
N. MEDIAN
N. MEDIAN
N. ULNAR
M. BICEPS
N. MUSCULO-CUTANEOUS
M. PALMARIS LONGUS
M. PRONATOR RADII TERES
M. FLEXOR CARPI ULNARIS
N. ULNAR
M. BRACHIALIS ANTICUS
N N. MEDIAN AND ULNAR
M. CORACO BRACHIALIS



Labeling Key

Upper Extremity
1. Abductor pollicis longus
2. Extensor digiti minimi
3. Extensor indicis
4. Flexor carpi radialis
5. Flexor carpi ulnaris
6. Other:
7. Other:
8. Other:
9. Other:
10. Other:

Lower Extremity
A. Abductor digiti minima
B. Extensor hallicus longus
C. Peroneus longus
D. Extensor digitorum brevis
E. Tibialis anterior
F. Other:
G. Other:
H. Other:
I. Other:
J. Other:

Activity Questions

1. Compare your findings with those of your subject. Do the motor points approximate those on the chart? What would explain any differences?

2. If you are using a unit where a polarity change is possible, try the following: Change the polarity from negative to positive. Move to an identified motor point and increase the intensity until a similar contraction is elicited. Did the required intensity change from your initial trial?

3. Is it possible to obtain a muscle contraction if electrode placement is not over a motor point? Why or why not?

ACTIVITY 4–7

Influence of Varying Electrical Stimulation Parameters

Objective

To become familiar with the various parameters available on electrical stimulators and how changing those parameters influences perception of the current.

Materials

- Various electrical stimulators (may include units with multiple-current types)
- Instruction manuals (including manufacturer specifications) for each stimulator

Procedures

1. Review the instruction manuals to determine the specifications for the unit (e.g., current types available, wave forms), and complete the chart appropriately.
2. Using the subject's forearm or thigh, configure the electrodes in a formation appropriate to the type of current being assessed.
3. Select an available parameter from the list below.

Possible Parameters	**Sequence of Activity**
Frequency:	High to low
Polarity:	Positive or negative
Pulse duration:	Long to short
Interpulse interval:	Short to long
Wave form:	Any sequence
Ramp time:	Zero to short to long
Current modulation:	Continuous frequency modulation amplitude modulation, multiple modulations
Sweep time:	Short to long

4. Increase the intensity until the subject feels a comfortably strong sensation, and note the intensity.
5. Reduce the intensity to zero, and vary the parameter in the direction indicated. Increase the intensity to the initial level.
6. Record the subject's comments about the different sensations in the space provided.
7. Repeat Steps 3 through 6 using a different parameter.

Note: If you are using a parameter not listed above, ask your instructor what sequence to use.

Influence of Varying Electrical Stimulation Parameters

Name: ______________________ Date: ______________________

Subject(s): ______________________

Name/Manufacturer of Stimulator: ______________________

Available Current Types:		
☐ Monophasic	☐ Biphasic	☐ Microcurrent
☐ Alternating	☐ Direct Current	☐ Interferential Current
Type of Current Used:		
Parameter Varied	Specifics: Tested	Comments (Perceptual change as parameter is varied)

Available Current Types:		
Monophasic	Biphasic	Microcurrent
Alternating Current	Direct Current	Interferential Current
Type of Current Used:		
Parameter Varied	Specifics Tested	Comments (Perceptual change as parameter is varied)

Activity Questions

1. Varying what single parameter most greatly influenced your perception of the current?

2. What combination of current parameters created the most comfortable current? The least comfortable?

3. For what purpose would a current ramp be used?

4. What is the benefit derived from modulating the current? Under what conditions is this parameter best used?

Neuromuscular Strength Augmentation

Objectives

- To demonstrate the use of several forms of electrical stimulation to elicit a muscle contraction of the quadriceps muscle group.
- To appreciate the comfort levels and effectiveness of each form of electrical stimulation and how changing parameters and electrode configurations can influence the comfort level and effectiveness.

Materials Needed

- High-volt pulsed stimulator
- Neuromuscular electrical stimulator
- TENS unit
- Russian stimulator
- Electromagnetic or hydraulic isokinetic dynamometer or hand-held dynamometer

Measuring Electrically Induced Muscle Contractions

An electrical current can be used to evoke a muscle contraction. Several factors influence the quality of these contractions, including the type of current, pulse duration, pulse frequency, output intensity, and electrode placement. The intensity of these contractions may be measured quantitatively using commercially available isokinetic units by comparing the force produced by an electrically induced involuntary isometric contraction (IIC) to that obtained by a maximal voluntary isometric contraction (MVIC).

After locking the limb in the position to be tested, the subject performs a maximal isometric contraction of the quadriceps muscle, and the value is recorded. An electrical stimulation unit may then be configured to the extensor musculature, and the force of the contraction is again measured (Fig. 4–7). Note that when the leg is hanging on the dynamometer, the output will read in negative numbers (e.g., -14 ft-lb). This represents the force of gravity placing a force opposite that of the movement. Once the contraction, voluntary or involuntary, exceeds the force of gravity, these numbers will read as positive values.

The percentage of the MVIC obtained is determined by the formula: (IIC/MVIC) $\times$ 100.

Procedures

1. Use of an isokinetic unit is recommended for this activity. If not available, a hand-held dynamometer may be substituted.
2. Set up the isokinetic dynamometer for isometric knee extension testing at approximately 70° of flexion according to the manufacturer's instructions.
3. Using the protocol specific to the dynamometer used, determine the person's MVIC force.
4. Instructions for use of a hand-held dynamometer during testing are provided with each electrical stimulation unit. For specific directions on the use of a hand-held dynamometer, refer to the manufacturer's manual.

   High-Volt Pulsed Stimulator

   1. Establish the baseline strength of the subject by asking for a maximal voluntary isometric muscle contraction against the dynamometer placed over the anterior ankle of the subject.

Figure 4–7. Set-up for testing force of contraction.

2. As high-volt pulsed stimulation uses a direct current, first decide what type of polarity will be used and what type of electrode configuration will be used. Begin with negative polarity and a monopolar electrode configuration. The smaller active electrode should be designated the negative pole. Place the dispersive electrode on the hamstrings or gastrocnemius of the same leg.
3. Place the active electrode over the motor point of the quadriceps muscle group after cleaning the area appropriately to reduce resistance.
4. Pulse frequency should be set at 10, 20, 40, 60, and 100 pps. Note the comfort level and effectiveness of contraction with the different frequencies.
5. Set the on and off time or duty cycle. For strengthening purposes, an on time of 10–15 seconds with an off time of 50 seconds to 2 minutes is warranted. Also attempt an on:off time of 5:5. Note the differences in fatigue after 5–10 minutes of treatment.
6. If pulse duration is variable within the machine, adjust it to 200–600 μsec.
7. Increase the intensity gradually according to the subject's responses.
8. Measure the torque produced by the electrically induced muscle contraction by using the hand-held dynamometer as before.
9. Ask the subject to rate the pain or comfort level on a VAS or 0–10 scale.
10. Adjust the parameters in Steps 2–6, and note comfort level changes and torque changes.

TENS Unit

1. As before, determine the baseline torque of the subject through the hand-held dynamometer and a maximal voluntary isometric contraction.
2. As most TENS units are alternating current (AC), the typical electrode configuration will be bipolar. Place the electrodes over the motor points of the quadriceps muscle group. You may alter the placement later to determine the most effective and comfortable placement.
3. Set the pulse frequency to 10, 20, 40, 60, and 100 pps. Note the comfort level and effectiveness of contraction with each frequency.
4. Set the on and off time or duty cycle. As with HVPS, the on and off time for strengthening is most effective at 10–15 seconds on and 1–2 minutes off. Adjust the on:off times later to determine the effect on fatigue and comfort.
5. Adjust pulse duration to the motor levels of 200–600 μsec. Also note the quality of the muscle contraction with pulse durations below 200 μsec.
6. Increase the intensity gradually according to the subject's responses.
7. Measure the torque produced by the electrically induced muscle contraction by using the hand-held dynamometer at the anterior ankle.

Russian Stimulator

1. Establish the baseline as before with an MVIC and the hand-held dynamometer.
2. Russian stimulators typically deliver medium-frequency (2000–10,000 Hz) wave carriers of polyphasic AC. Pulse duration and pulse frequency are usually adjustable. With AC, bipolar electrode configurations are typically used. Place the electrodes over the motor points of the quadriceps muscle group. Placement can be altered later to determine the most comfortable and most effective for muscle contractions.
3. Set the pulse frequencies at 10, 20, 40, 60, and 100 pps. Note the comfort level and effectiveness of contraction with the different frequencies.
4. Set the on and off time or duty cycle. On time of 10–15 seconds with off time of 1–2 minutes is warranted for strengthening purposes.
5. If pulse duration is adjustable within the machine, adjust it from 50–600 μsec, and note the quality of the muscle contraction and comfort level with each new setting.
6. Increase the intensity gradually according to the subject's responses.
7. Measure the torque produced by the electrically induced muscle contraction via the hand-held dynamometer.
8. Also note the comfort level with the VAS or 0–10 scale.
9. Adjust the parameters above, and note changes in muscle contractions and comfort levels.

Notes

- Allow sufficient time for muscle recovery between bouts.
- This activity may be modified by altering the output parameters and electrode placement as well as changing the position of the lower extremity.
- It is common for the subject to experience muscle soreness following this activity.

Neuromuscular Strength Augmentation

Name: ______________________ Date: ______________________

Subject(s): ______________________

Maximal Voluntary Isometric Contraction		
Subject	Joint Angle	Peak Torque

Subject	Electrical Stimulator	Electrode Configuration	Pulse Duration	Pulses Per Second	Duty Cycle	Max. Output Intensity	Pain (0–10)	Joint Angle	Peak Torque	%MVIC

Activity Questions

1. Based on the activity, would you expect a stronger contraction using a monopolar or bipolar pad arrangement?

2. Considering your results, which electrical stimulator would you use to obtain an optimal muscle contraction? Why?

3. Following a period of rest or using the opposite leg, determine the IIC using various duty cycles by altering the rest duration. What can be deduced from this activity regarding the implication of fatigue in electrically assisted muscle contractions?

4. You are attempting to strengthen the vastus medialis oblique with a bipolar set-up over the anterior thigh but are unable to elicit a muscle contraction before the subject complains of discomfort. What can you do to make the patient more comfortable and still elicit a muscle contraction?

ACTIVITY 4–11

Pain Control Using Electrical Stimulation

Objective

To determine comfort of different electrical stimulation units and the different parameters used to control pain.

Materials Needed

- High-volt pulsed stimulator
- Interferential electrical stimulator
- TENS unit

Procedures

1. Clean the area appropriately to reduce resistance.
2. Set the parameters for pain control using the charts below.
3. Increase the intensity gradually according to the subject's responses.
4. Ask the subject to rate their pain or comfort level on a VAS or 0–10 scale.
5. Use several different pain control settings and record the treatment parameters and subject comfort score on the chart provided.

High-Volt Pulsed Stimulator			
Parameters	**Gate control mechanism**	**Opiate release mechanism**	**Brief-intense protocol**
Output intensity	Sensory level	Motor level	Noxious
Pulse frequency	60–100 pps	2–4 pps	>120 pps
Phase duration	<100 μsec	150–250 μsec	>300 μsec
Mode	Continuous	Continuous	Probe (15–60 sec per site)
Electrode arrangement	Monopolar or bipolar	Monopolar or bipolar	Monopolar (probe)
Polarity	Acute: positive; Chronic: negative	Acute: positive; Chronic: negative	Acute: positive; Chronic: negative
Electrode placement	Directly over the painful site	Directly over the painful site, distal to the spinal nerve root origin, trigger points, or acupuncture points	Gridding technique

Note: Not all parameters will be applicable to each unit.

TENS			
Parameters	**High-frequency TENS**	**Low-frequency TENS**	**Brief-intense TENS**
Output intensity	Sensory level	Motor level	Noxious
Pulse frequency	60–100 pps	2–4 pps	Variable
Phase duration	60–100 μsec	150–250 μsec	300–1000 μsec
Mode	Modulated	Modulated	Modulated
Electrode arrangement	Direct or continuous	Direct or continuous	Direct or continuous

Note: Not all parameters will be applicable to each unit.

Interferential Stimulation		
Parameters	**Gate control**	**Opiate release**
Carrier frequency	Based on patient comfort	Based on patient comfort
Burst frequency	80–150 Hz	1–10 Hz
Sweep	Fast	Slow
Electrode arrangement	Quadripolar	Quadripolar
Electrode placement	Around the periphery of the target area	Around the periphery of the target area
Output intensity	Strong sensory level	Moderate to strong sensory level

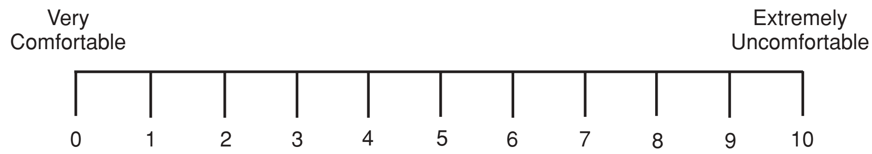
Note: Not all parameters will be applicable to each unit.

Pain Control Using Electrical Stimulation

Name: ______________________ Date: ______________________

Subject(s): ____

Comfort Scale



Using the comfort scale provided, complete the following table by writing the comfort score in the space provided.

Subject	Stimulator/Treatment parameters	Comfort score (0–10)

Activity Questions

1. Which unit and set-up appeared to be the most comfortable? Which was the most uncomfortable?

2. If you were planning to treat an elderly patient with chronic pain and the patient seemed apprehensive to the use of electrical stimulation, what unit and treatment protocol might be the most appropriate? What could you do to prepare the patient for the treatment and calm the concerns about electrical stimulation?

CASE STUDIES FOR UNIT 4

On completion of the activities for Unit 4, review the following case studies to enhance practical application of electrical modalities.

1. Following a 6-week immobilization of an ankle fracture, a cross-country runner is in need of peroneal strengthening. Which type of electrical stimulation would you use? Describe the set-up parameters for the treatment.

2. A laborer is being treated for lateral epicondylitis and displays weakened grip strength. You decide to use HVPS. Describe the parameters you would use. Also decide what type of electrode configuration you would use.

3. Explain the differences in duty cycle or on-time and off-time you would use if you were concentrating on increasing muscular endurance for the external rotators of a college pitcher or if you were concentrating on increasing muscular strength of the gastrocnemius of a college wrestler.

4. Your patient is a 56-year-old man with severe pain and decreased range of motion of his left shoulder. The pain is diffuse over a large portion of his shoulder. His pain appears to be secondary to a deltoid strain suffered 2 weeks ago while he was doing yard work. Describe the treatment options you have for treating this patient's chief complaint of pain.

5. Your patient is a 35-year-old tennis player with elbow tendonitis. He has been doing conservative treatment for 3 weeks, with little improvement in the tendonitis. He wants to play in a community tournament in 2 weeks. Your facility has the equipment to provide iontophoresis. Is this a good choice for treating this condition? If you choose to use iontophoresis, what is the set-up for the treatment? Be sure to include all necessary parameters.