The Effect of Verbal Commands on Muscle Performance

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The Effect of Verbal Commands on Muscle Performance

by

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Molly K. Veen

THESIS

Submitted to the Department of Physical Therapy
at Grand Valley State University
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THE EFFECT OF VERBAL COMMANDS AND MUSCLE PERFORMANCE

ABSTRACT

The purpose of this study was to determine if a relationship exists between voice command intensity and maximum torque production of an isometric muscle contraction. Thirty nine healthy subjects ranging in age from 18-30 participated in this study. The maximum torque production of triceps brachii was measured using a Cybex II+ isokinetic dynamometer in response to varied, tape recorded voice commands. Data was analyzed by a series of analysis of covariance (ANCOVA) and analysis of variance (ANOVA) for an unbalanced incomplete-block crossover trial design. No significance was found between voice intensity and peak torque. Gender was found to impact torque production, and accounted for all differences noted (P<.05). Further research in this area is warranted due to small sample size and the results of this study conflicting with those of an earlier study.
DEDICATION

Lisa would like to dedicate this thesis to the following individuals:

To my family (especially Dad & Mom) whose encouragement and loving support provided me with the means to follow my dreams.

To Ana Margarita, the sister I never knew, whose short life on earth inspired me to pursue physical therapy.

To my friends (you know who you are) who so graciously supported me with prayers and listening ears.

Molly would like to dedicate this work to the following individuals:

To my family whose guidance and support helped bring this dream to completion.

To my friends (you know who you are too) for your patience and understanding these past three years. It was greatly appreciated.
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PREFACE

Definition of Terms

**Alpha motor neurons** - A nerve cell that controls (innervates) skeletal muscle fibers (extrafusal fibers).

**Ambient** - on all sides, surrounding

**Anechoic chamber** - A room constructed so that it absorbs sound waves.

**Audio-spinal potentiation** - Excitability of spinal motor neurons is enhanced or facilitated through auditory stimuli; which in turn enhances a reflex response or if properly timed may facilitate motor events to rhythmic stimulation such as music (Rossignol & Jones, 1976).

**Binaural** - of or relating to both ears

**Decibel (dB)** - the unit of the intensity measurement for sound. It is a physical measure not a reference for subjective magnitude of sound. It is a logarithmic unit used to express the relative magnitude of two quantities as measured by a sound level meter.

**A-weighting (dB(A))** - A scale that was created to reflect the subjective loudness of sounds.

**Sound pressure level (dB(SPL))** - A scale based on an agreed upon reference level that allows for a simple comparison of different quantities of acoustic energy. This scale can be A-weighted in order to mimic the normal sound filtering of the ear.

**Depolarization** - to change a nerve membrane potential (voltage) so that the cell interior becomes less negative and will fire
**Electro-oculograph** - A machine that records the measurement of voltage between the front and back of the eye, used in studying eye movement.

**Electromyograph** - A device used to record electrical voltage generated by muscles in the body.

**Facilitation** - The enhancing of a response, making it easier to obtain the desired output.

**Fusimotor** - the gamma motor neurons that innervate the muscle spindles.

**Gamma motor neurons** - a small nerve cell that controls muscle spindle fibers (intrafusal).

**Habituation** - to make familiar by repetition, so it no longer elicits as great a response.

**Hyperpolarization** - to change a nerve membrane potential (voltage) so the cell interior becomes more negative than its resting state and less likely to fire.

**Isometric**- a type of muscle contraction in which force is produced, but no actual movement occurs.

**Isokinetic**- a type of muscle contraction in which the speed of movement is fixed, and the resistance accommodates to the effort of the patient.

**Muscle spindle** - a sensory receptor found within the intrinsic fibers of a muscle. It is sensitive to stretch and has an influence on the resting tone of a muscle.

**Myogenic** - originating in muscle

**Phasic** - intermittent. Muscles described as phasic are responsible for bursts of movement with strength and power, and contribute to range and speed of movement.
**Tonic** - continuous. Muscles described as tonic contribute to endurance and postural alignment.

**Torque** - A parameter of muscle performance that is measured by isokinetic dynamometers. Torque is rotational force.

**Peak Torque** - The maximum torque production during an extension/flexion; measured in foot-pounds (ft.-lbs.)

**White noise** - A nondescript static sound used to mask distracting or annoying sound.
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CHAPTER 1

Introduction

The volume of a verbal command is assumed to enhance the performance of a physical activity in many physical therapy treatments. For example, neurological treatment techniques such as proprioceptive neuromuscular facilitation (PNF), Rood, and Brunnstrom all advocate the use of verbal stimulation to facilitate the nervous system. PNF holds as part of its theoretical framework that verbal command volume and tone provide a stimulus to augment muscle response (Voss, Ionta, & Myers, 1985). A strong command is used to obtain the maximal response. Verbal communication is also said to motivate the patient (Voss et al., 1985). Rood theory claims that a person's central state can be influenced by both volume and tone of voice. The term central state is used by Rood to indicate an individual's mental and physical status, which determines their readiness for function (Attermeir, 1984). Dynamic verbal commands lead to arousal of the cortical component of central state (Sullivan, Markos, & Minor, 1982). Finally, Brunnstrom technique uses auditory stimulation as part of its sensory input in order to gain voluntary control of muscle synergies (Montgomery & Connolly, 1993). This technique employs loud verbal commands in the early stages of stroke rehabilitation to add to the input to the nervous system. Summation of facilitatory inputs is believed to trigger movement (Sawner & LaVigne, 1992). These theories have not been supported by researched findings, but are based on observed outputs following auditory stimulation,
and proposed neuromechanisms. Providing evidence for these underlying assumptions will fortify the theoretical framework of these facilitation approaches.

A study by Johannson, Kent, and Shepard (1983), found a positive correlation between the force of muscle contraction and the intensity of verbal command (the higher the intensity, the higher the force). The commands ranged in intensity from 66 decibels on the A-weighted scale (dBA) (low volume) to 88 dBA (high volume). The commands consisted of "push, push, push" as the subjects were instructed to push against a tensiometer cuff using their elbow extensors (triceps brachii).

There are several limitations to the study by Johannson et al. (1983). The first limitation is in the area of design. The researchers did not take into account order effects, since subjects were not randomly assigned to alternate forms of the experimental design (ABAB only, versus the use of both BABA and ABAB). Another limitation is evident in the researchers' choice of subjects. Only males were chosen to participate in this study and a possible difference in perception of verbal commands may exist between the sexes. The small sample size (19 males) is another weakness of the Johannson et al. study. A further limitation exists in the area of the equipment utilized; the treatment table lacked adequate stabilization of the patient during the muscle contraction. Finally, a problem was found in the choice of decibel levels used in this study. The authors stated that 78 dBA was considered to be normal volume of speech. However, 78 dBA tends to be in the high range of normal speech volume. Thus, in choosing their high volume command intensity (88 dBA) the researchers could have elicited the startle reflex (85
dBA) (M. Arsenault, personal communication, June 26, 1995). This reflex potentially has the ability to bias the results.

Many sensory elements are assumed to facilitate muscle contraction, but have not been adequately supported by research. We have chosen to investigate the element of voice volume. The purpose of this study is to determine if a relationship exists between the intensity of voice command and the maximum torque production of an isometric muscle contraction. Should a relationship exist between the intensity of verbal command and a subsequent muscle contraction, this association would also be relevant to evaluative techniques. In order to maintain accuracy during manual muscle testing, the consistency of voice volume would be essential for obtaining reliable results across repeated measures. This association between command volume and muscle performance would also be relevant in the areas of isokinetic testing and other testing procedures in which verbal commands are commonly used.

The question of interest to the study is: does the intensity of voice command have an effect on the maximum torque production of a subsequent isometric muscle contraction in healthy individuals between the ages of 18-30 years? This study will be a variation of that performed by Johannson et al. (1983). Modifications will be made in the areas of design, equipment, subjects, and decibel levels.
CHAPTER 2

Literature Review

The neurophysiologic rationale for sensory elements is often vague, and individual differences in response patterns exist, so techniques should not be applied indiscriminately. Responses to sensory elements can vary depending on the parameters of rate, duration, frequency, location and type of stimulus (Sullivan et al., 1982). A response to a sensory element could be a localized phasic or tonic response or a more widespread, generalized response depending on the element and method of application. Examples of facilitatory techniques that augment motor response include: light moving touch, brushing, quick ice, repetitive ice, firm pressure, quick stretch, traction, compression, noxious odors, and visual elements in the form of bright colors, intermittent visual stimuli, and moving stimuli, and intense auditory stimuli (Umphred & McCormack, 1990).

In this study, the sensory modality of auditory stimulation will be investigated. Following vision, the auditory system is considered to be the second most important exteroceptive sense. It allows us to perceive occurrences in the surrounding external environment (Umphred & McCormack, 1990). The use of auditory stimuli is theorized to have both localized/generalized, phasic/tonic, and facilitatory/inhibitory responses according to how it is used (Sullivan et al., 1982). Treatment alternatives within auditory stimulation include: quality of voice (pitch and tone), quantity of voice
(level and intensity), affect of voice, and extraneous noise. This study will focus on voice intensity and its use in obtaining a maximal motor output.

**General Physiology**

The human auditory system is very complex. Sound waves are collected from the environment by the auricle (ear), travel through the auditory canal (external auditory meatus) until they meet the tympanic membrane (ear drum). The sound waves cause vibration of the tympanic membrane and these vibrations are transferred from the membrane towards the ossicles. There are three ossicles: the malleus, incus and stapes (hammer, anvil, and stirrup). The vibrations initiated by the tympanic membrane spread successively from the malleus, to the incus, to the stapes. The stapes is connected to the oval window of the cochlea; thus, vibration of the stapes conducts sound waves into the endolymph of the cochlear duct. The cochlear duct is a fluid-filled tunnel that contains the sensory organ of Corti. The sensory organ of Corti is the organ of hearing and is located on the inner surface of the basilar membrane. It is made up of supporting cells and hair cells (stereocillia). The organ of Corti translates the sound waves from the environment into neural impulses (Ballou, 1987). The mechanism of translation proceeds in the following manner: 1) the sound waves in the endolymph cause movement of the basilar membrane; 2) movement of the basilar membrane will cause the tectorial membrane, which is suspended superiorly and horizontally to the stereocillia, to produce a horizontal shearing force across the surface of the stereocillia; 3) movement of the stereocillia in one direction produces depolarization, while movement in the opposite direction produces hyperpolarization (Netter, 1992).
The neural impulse travels to the acoustic area in the temporal lobe of the cerebral cortex via a pathway that involves several nuclei. The impulse initiated by the bending of the stereocilia is carried by the cochlear branch of the vestibulocochlear cranial nerve (VIII) to the cochlear spiral ganglion. It then proceeds along the VIII cranial nerve to the dorsal and ventral cochlear nuclei in the lateral aspect of the inferior cerebellar peduncle of the brain stem. From here the impulse travels to the superior olivary complex (in the medulla oblongata), to the nucleus of the lateral lemniscus, to the inferior colliculi nuclei, and to the medial geniculate body, which then carries the impulse to the primary auditory area (Brodman's 41) in the temporal lobe of the cerebral cortex (Netter, 1992).

The ascending impulse does not always relay at each nucleus along the pathway. The primary relay is to the dorsal and ventral cochlear nuclei, while the final relay is to the medial geniculate body. The other relays are intermediate and an impulse may bypass one or two of the intermediate nuclei along its destination to the medial geniculate body. Fibers ascend both contralaterally and ipsilaterally. The ascending pathway is organized tonotopically, that is, each nucleus and neuron is excited by a narrow range of sound frequencies and may be inhibited by tones outside that frequency (Netter, 1992).

Netter (1992) describes a descending centrifugal (efferent) auditory pathway. This efferent pathway involves the nuclei of the ascending pathway, and includes the motor nucleus of the trigeminal nerve and the facial nucleus. These centrifugal connections project one or two levels below their point of origin. Inhibition of transmission of auditory signals through the ascending pathways is what appears to activate the centrifugal pathway. The terminations of this pathway include the cochlear
hair cells, afferent nerve terminals, and the muscles of the middle ear (stapedius and
tensor tympani muscles). The efferents to the cochlear hair cells and afferent nerve
terminals cause hyperpolarization which results in a decrease of afferent activity. The
efferents to the muscles of the middle ear produce contraction of the stapedius and tensor
 tympani muscles which results in a decrease of sound vibrations that enter the oval
window. The purpose of this centrifugal pathway is not well understood, but it is clear
that these connections are important in controlling man's responses to auditory stimuli

Evidence of a descending auditory pathway that affects the motor nuclei in the
anterior horn of the spinal cord comes from reflex studies and evoked potential studies.
Sakano and Pickenhain (1966), Pal'tsev and El'ner (1967), Buchwald (1967), Gernandt
and Ades (1964), and Johansson, Kent, and Shepard (1983) all suggest that the audio­
motor pathway results from connections of the reticular formation to the spinal cord.
However, the reticular formation is not considered part of the classical auditory system.
The reticular formation is a loosely organized collection of cells in the brain stem. It
originates in the nucleus reticularis gigantocellularis, nucleus reticularis pontis caudalis,
and the nucleus reticularis pontis oralis. Its termination is on the anterior horn cells
extending inferiorly to the lumbar spinal segments. Sakano and Pickenhain claim that an
acoustic stimulus initiates a massive series of impulses that reaches the reticular
formation, thereby eliciting an "explosive, generalized innervation of the motor system."
Pal'tsev and El'ner propose that the effects of sound stimulation spread not only to the
ascending pathways but also influence the descending pathways, which in turn influences
the spinal cord's functional state. Pal'tsev and El'ner indicate that these spinal cord
influences are closely connected with the activation of pathways that originate in the
nuclei of the brain stem and suggest that this increase in motor neuron excitability may be
caused by brain stem reticular formation connections. Buchwald indicates that
descending auditory signals reach the spinal cord motor neurons via the medial
longitudinal fasciculus and reticular formation projections. Ades and Gernandt suggest
that descending auditory-motor pathways occur by means of lower brain stem reticular
formation connections, specifically that of the reticulospinal tract. Johansson et al.
propose that, "auditory discharges are relayed to motor neurons through the spinal cord
projections of the reticular formation and through the tectospinal tract." Bickford,
Jacobson, and Cody (1964) stated that motor neurons were stimulated via the vestibular
spinal tract. These studies suggest that there is a descending auditory motor pathway.
However, the details of this pathway's connections to the spinal cord are not well
understood.

**Reflex Responses to Auditory Stimulation**

The auditory system has motor reflex connections. This connection is clearly
demonstrated through startle and orienting reactions to auditory stimuli (Buchwald,
1967). The startle reflex is typically described as a flexor response that occurs as a result
of a sudden loud noise. It is a response that remains throughout life (Crutchfield, Barnes,
1993). The orienting reaction is a response to sound stimulation that results in turning of
the head toward the source of the noise.
Buchwald (1967) states that the auditory-motor pathway begins at the auditory nerve which synapses with the cochlear nuclei. The cochlear nuclei (brain stem) has further connections with the inferior colliculus and medial geniculate body of the thalamus (higher auditory centers). From there the signal may pass to one of three areas: (1) the auditory area of the temporal cortex, (2) the medial longitudinal fasciculus (midbrain), or (3) the reticular formation (Buchwald, 1967). Auditory signals arrive at motor neurons through relays from the medial longitudinal fasciculus and reticular formation. Moderate auditory signals elicit responses in gamma motor neurons, which can be excitatory or inhibitory; more intense auditory signals affect the alpha motor neurons (Buchwald, 1967). Reflex integration occurs through brain-spinal cord connections, but how these connections affect voluntary movement remains ambiguous.

One of the findings in a study by Gogan (1969), was that the stronger the auditory stimulus the larger the startle, whereas orienting reactions could be elicited by both high and low intensity stimuli. The motor activity of this study was recorded by electromyograph (EMG) from various muscles of the neck, face, and arms. After the sound stimulus each EMG recording contained an initial burst of activity followed by a period of decreased muscle activity, and then a second late response (Gogan, 1969). The early response was considered to be the EMG recording of startle, whereas the late response was the recording of the orienting reaction. The sound stimulus consisted of bursts of white noise (a nondescript sound used to mask annoying sound) at 20-20,000 cps delivered to the subject in an anechoic (a room that absorbs sound waves) chamber (ambient noise 20 decibels [dB]). The sequence used to determine the stimulus
relationship to startle response was one burst each ten seconds at three different
intensities of 92 dB, 66 dB, and 32 dB respectively (Gogan, 1969).

Another study involving startle and auditory stimuli was performed by Rossignol
(1975). EMG patterns of startle reactions were recorded from the ankle of a man with
surface electrodes over the tibialis anterior and gastrocnemius. The stimulus that elicited
the startle was a 100 msec one kilocycle per second (kc/sec) square wave tone burst of
114 dB. He found that startle was elicited three times more frequently in the flexors than
the extensors. Extensor startle tended to appear either during ongoing activity of the
extensors or at rest following momentary movement of the extensors. If the ankle was in
tonic flexion or extension, the EMG recorded a superimposed burst at a latency of 150
msec followed by a silent period lasting 100 msec which began at 200 msec. Similar
silence occurred without a previous documentation of EMG startle. This silent period
indicates a possible inhibitory portion of the audiospinal mechanism. It is believed to be
related to startle as it has not been documented in studies using non-startle stimuli.

The acoustic blink reflex was once considered part of the startle reaction;
however, current research suggests that it is not part of the true startle response. The
acoustic blink reflex is an auditory reflex that occurs regardless of a more generalized
response. This reflex has been used clinically in the neurological examination of
unconscious patients with hand-clapping as the auditory stimulus. Saring and
vonCramon (1981) did a study to determine the diagnostic value of this practice.
Included among their findings was that: (1) an increase in auditory stimulus intensity
results in an increase in amplitude of eye-blinks, and (2) an increase in auditory stimulus intensity increases the occurrence of a reflex blink.

Although the startle reflex is the most notable auditory-motor connection, less discernible interactions also produce an excitatory response. A study by Rossignol and Jones (1976) utilized a non-startle auditory stimulus (one kc/sec sine wave tone burst of 100 msec at 110 dB) to determine its effect on the H-reflex of the gastrocnemius/soleus complex, which occurs through stimulation of the popliteal nerve. The H-reflex, stimulated by a spring loaded cathode, increased in amplitude following application of the auditory stimulus. The latency of the facilitation was 80 msec with a peak at 110-130 msec, and a mean duration of 200 msec. They found a low habituation rate, and no inhibition followed the excitatory period. Similar results of audio-spinal potentiation were found when Rossignol and Jones performed further investigations where vertical acceleration, and make and break of foot contact were recorded, by EMG, as a subject hopped to a below startle traditional Scottish reel.

Ten male subjects participated in a Davis and Beaton (1968) study to obtain quantitative data of auditory facilitation of the quadriceps stretch reflex. The stimulus intensities were no tone, 97 dB, and 108 dB (1,800 cps) with 20 of each randomly delivered 0.25 sec preceding tendon tap elicited by a 1,400 gram ellipsoid weight. The 108 dB tone resulted in the greatest response. The facilitation effect was greatest the first time the stimulus were delivered. Throughout the experiment the difference made by the auditory stimuli remained but the effects were not as great. The adaptation was not as evident where there was not a facilitatory tone. The researchers also performed a test in
which the highest intensity stimulus was eliminated and a total of 100 stimuli were presented, complete adaptation still did not occur.

The previous studies indicate that reflexes are facilitated by a prior auditory stimulus. However, a study by Reiter and Ison (1979) concerning reflex modulation concluded that the amount of inhibition or "reflex modulation" is positively correlated with the loudness of the tone. The reflex studied was the eye-blink elicited by an airpuff and the amplitude was measured by an electro-oculograph. In the experiment involving seven subjects the intensities of the auditory stimuli were 65, 73, 81, 89, and 97 dB sound pressure level (SPL), each given 100 msec prior to the airpuff (Reiter et al., 1979). The greater the auditory stimulus intensity, the less the amplitude of eye blink.

Finally, in a study by Burg, Szumski, Struppler, and Velho (1973) acoustic stimulation (administered by hand clapping) was found to increase muscle spindle firing, yet the golgi tendon organ failed to be activated. The increase in muscle spindle firing was enhanced and longer lasting if the acoustic stimulus was unexpected. This study found that an acoustic stimulus resulted in activation of the fusimotor system.

Evoked Potential Studies

An evoked potential is a tracing of a brain wave. Surface electrodes are placed on the head at various locations. These electrodes enable brain waves to be traced via an electroencephalograph (Glanze, 1992). Evoked potentials show the cortical responses to specific stimulation. In the following cases, the evoked potentials deal with the responses of the brain to auditory stimulation. Tests of auditory evoked potentials are used to provide information on the functional status of the ear and the nervous system. These
tests also provide information on how the brain responds to acoustic stimulation (Glattke, 1983).

One of the earliest studies on evoked potentials that describes a relationship between an auditory stimulus and a muscular response is that by Bickford et al. (1964). In this study, subjects (30 normal and 4 with known lesions of the audiovestibular system) were subjected to binaural auditory stimulation in the form of 120 decibel clicks. Surface electrodes were located at the inion (a protuberance on the midline of the occipital bone) and data was collected via computer. The results of this auditory stimulation showed clearly defined responses of short latency recorded by the electrodes. Due to this short latency (6-8 msec) of response, questions were raised as to whether these responses were cortical or myogenic in nature. Therefore, Bickford et al. ran further tests to determine the responses to click stimulation from the arm and legs. The results from these further investigations revealed that, when background muscle tension was provided, there were clearly defined responses to click stimulation in both the arm and the leg muscles. The findings showed that there is a general widespread response system to sound stimulation detected by response averaging of EMG data. No grossly detectable movement was noted. Bickford et al.'s investigation of the source of this response system suggested that the response to sound-click stimulation did not involve the voluntary or the startle systems. Rather the investigators concluded that the source was from the vestibular system. The researchers came to this conclusion by studying the responses to click stimulation on subjects with known lesions of the audiovestibular system. They found that the myogenic responses did not occur in subjects with impaired
vestibular systems. However, myogenic responses were elicited in subjects with properly functioning vestibular systems. Bickford et al. suggested that a possible pathway of transmission for the myogenic nature of the evoked responses would involve the vestibulospinal tract.

Cody, Jacobson, Walker, and Bickford (1964) performed a study on averaged evoked myogenic and cortical components to sound in man. In this experiment subjects (both healthy and audiovestibular lesions) were exposed to clicks generated by a stimulator. The responses to the clicks were recorded by electroencephalographic electrodes and analyzed via computer. The results of this investigation indicated that there were two types of responses to auditory stimulation, an inion response and a vertex response (most superior part of the skull). The inionic response appeared to be myogenic in nature, and the evidence from the study suggested that this response was mediated by the vestibular apparatus of the inner ear. The vertex response seemed to be cortical in origin and evidence suggested that it was mediated by the cochlea. The findings indicated that a stimulus between 85-120 decibels was required to illicit both the inionic and vertex response, and that the amplitudes of the responses increased as the stimulus intensity was increased. The researchers were able to produce the same myogenic responses to click stimulation from the arm and leg that Bickford et al. (1964) produced.

Another study on evoked potential was done by Sakano and Pickenhain (1966). The study was undertaken to determine the relationship between auditory evoked cortical responses and the startle reflex in man. Subjects in this study were exposed to two different kinds of intense short duration acoustic stimuli: the shot of a starting pistol and
clicks produced by the discharge of a condenser. The recording electrodes were located on the skull over the vertex, on the left occipital region, on the upper and lower margins of the orbicularis oculi muscle, and on the neck muscles. The jerk of the head following sudden stimuli was also measured. The results showed that the presentation of shorter latency peaks of auditory cortically evoked responses correlates with the occurrence and larger amplitude of the startle reflex. The researchers also found that a cortical evoked response always occurred when a simultaneous startle reflex response was elicited by a relatively intense acoustic stimulus. The mechanism that the experimenters postulated for the excitation of the motor system and the cortical evoked responses is as follows: the acoustic stimulation results in excitation of the tegmental reticular formation while simultaneously exciting reticular ascending pathways.

The review of evoked potential studies indicates that there is a relationship between acoustic stimulation and a generalized response of the central nervous system. This generalized response includes activity that is myogenic in nature.

**Voluntary Studies**

Most of the work concerning the effects of acoustic stimulation in humans has been reflexive in nature. Very few studies have dealt with the voluntary aspect of motor response. One study by Pal'tsev and El'ner (1967) investigated the relationship between sound stimuli and voluntary movement. This study was particularly concerned with the change in the functional state of the spinal cord that occurred as a result of sound stimuli. This investigation involved two separate tasks. In the first task subjects were exposed to different intensities (20, 70, and 100 dB above the audibility threshold) of acoustic
stimulation. The effect of acoustic stimulation on the quadriceps reflex was measured. The results from this task revealed that the amplitude of the reflex response increased as the intensity of the stimulus increased. The researchers concluded that sound stimuli could influence the functional state of the spinal cord by means of impulses initiated in the brain stem, and that these stem-originating impulses could reach different levels of the spinal cord via connections with the reticular formation. The second task was designed to determine the relationship between sound stimuli and voluntary movement. Subjects in this task were exposed to different intensities of acoustic stimuli (20, 70, and 100 dB above the audibility threshold). The effect of the sound stimuli on the subject's reaction time to "extension of the shin" was then measured. It was discovered that the latency of response decreased as the intensity of the stimulus increased. The researchers hypothesized that the sound stimuli initiated impulses that spread not only through the ascending pathways but also spread to the spinal cord and increased, in an unspecified way, the motor neuron excitability. This spreading of impulses to the spinal cord was said to occur via brain stem formations.

Johansson, Kent, and Shepard (1983) did a study to determine the relationship between the volume of a verbal command and the force of a muscle contraction. Subjects in this study were exposed to different intensities of a command that consisted of "push, push, push". The intensities varied from 66 dBA (low volume) to 88 dBA (high volume). The subjects were asked to perform a voluntary isometric contraction of the triceps brachii muscle following a command to push. The force of the subject's voluntary muscle contraction was measured via a tensiometer. A significant difference was found
at the 0.05 level between the force of a muscle contraction and the intensity of a verbal command. This difference showed a direct relationship, the higher the volume the higher the force. Thus, a positive correlation was established between volume and motor response.

Only two studies on auditory stimulation and its relationship with voluntary muscle contraction have been done. The study by Paļtsev and El'ner (1967) solely investigated the effects that acoustic stimulation had on the latency of response of a voluntary contraction. The results from this study indicated that an auditory stimulus had an effect on a voluntary contraction, but it did not reveal if the stimulus had an effect on the force of a muscle contraction. The study by Johansson et al. (1983) is the only study to date that has examined the relationship between an acoustic stimulus and the force of a muscle contraction. Therefore, it is clear that this aspect of acoustic stimulation has not been widely explored. The conceptual framework of many physical therapy treatments holds as its premise a direct relationship between acoustic stimulation and motor response, yet very little evidence is available to support this premise.

**Cybex II+ (conceptual framework)**

The Cybex II+ is an isokinetic dynamometer that has the capability to quantitatively measure several aspects of muscle performance. These aspects of muscle performance are the isokinetic (fixed speed, accommodating resistance) measurements of "strength", power, and power endurance. The Cybex II+ is also able to record and measure isometric (force production without actual movement) muscle contractions. The isometric parameters that the Cybex II+ measures are time-rate of torque development,
peak torque and fatigue. The aspect of muscle performance that this study will be
concerned with is that of "strength." The handbook, Isolated -Joint Testing & Exercise,
A Handbook for Using Cybex II and U.B.X.T. (1980), defines "strength" as the
"maximum slow-speed torque capability." Therefore, muscle "strength" is inferred from
the measurement of torque and is used interchangeably. The specific torque parameter
that this study will measure is that of isometric peak torque. The Cybex's maximum
instantaneous torque capability is 360 foot-pounds (ft-lbs) while the maximum
continuous or repetitive torque capability is 240 ft-lbs. Therefore, the Cybex clearly has
the capability to measure the amount of torque production that an average individual
could produce, making it an appropriate instrument for this study. Another reason that
the Cybex is an appropriate measurement instrument for this study is that the Cybex's
U.B.X.T. (Upper-Body Exercise and testing Table) provides better patient stabilization
and positioning than many other testing tables. Finally, Grand Valley State University's
Physical Therapy Department owns a Cybex II+ which makes it a convenient choice.

The Cybex handbook provides accepted performance characteristics for the Cybex
II system. The characteristics that are important to note for this study are torque
measurement accuracy, torque measurement repeatability, and speed range. Torque
measurement accuracy (from one isokinetic system to another as well as comparison with
functional demands) is as follows: accuracy 360 ft. lbs. scale = +/- 4.0 ft. lbs, 180 ft. lbs.
scale = +/- 2.5 ft. lbs, 30 ft. lbs. scale = +/-1.5 ft. lbs. Torque measurement repeatability
(pertaining to the consistency of measurement of a single system for comparing
measurements made at one time to those made at another assuming calibration is checked
and adjusted) is as follows: 360 ft. lbs. scale = +/- 2.0 ft. lbs, 180 ft. lbs. scale = +/- 1.0 ft. lbs, 30 ft. lbs. scale = +/- 1.0 ft. lbs. The Cybex's speed range is 0-318 degrees per second (Isolated-Joint Testing, 1980).

**Cybex II Reliability Studies**

A study involving the reliability of the Cybex isokinetic dynamometer interfaced with a Cybex Data Reduction Computer was performed by Perrin (1986). Subjects underwent testing of the right and left knee flexor and extensor, and shoulder internal and external rotator muscle groups at 60 and 180 degrees per second. Reliability of peak torque, torque acceleration energy, endurance ratio, average power, and total work measures was determined through testing and repeat testing one week later. The investigator found, in general, slightly lower reliability measures for the shoulder than the knee. A possible explanation may be the larger range of motion that is necessary for testing the upper extremity isokinetic strength, which may involve greater variability in enlisting the accessory muscle groups. The highest reliability coefficients were demonstrated in peak torque, torque acceleration energy, average power, and total work measures and clinicians can assume greater reliability of instrumentation for these elements.

The Cybex II isokinetic dynamometer has been used for the measurement of maximal voluntary isometric contractions. One such study by Weir, Wagner, and Housh (1992) investigated both the linearity and reliability of the surface integrated electromyogram (IEMG) versus torque relationship for the forearm flexors and leg extensors. This element of linearity is an important aspect of an IEMG technique which
determines the contribution of muscle hypertrophy and neurological adaptation to strength gains. The IEMG measurements were recorded on a MODEL EMG 1000 digital multimeter, and a bipolar electrode placement was utilized. The Cybex II positioning for both the forearm flexors and the leg extensors followed manufacturer's recommendations with the exception that for the forearm flexors the U.B.X.T. was placed parallel to the dynamometer and the subject's arm was parallel to the U.B.X.T. IEMG and torque were recorded from a series of 12 isometric contractions. Each contraction was held for five seconds with the first and last contraction being maximal and all other contractions being submaximal represented by 10, 20, 30, 40, 50, 60, 70, 80, and 90% of the maximum. These submaximal percentages were determined by the subject's subjective reports. The investigators found that for both the forearm flexors and leg extensors there was high test-retest reliability for both the maximal torque and IEMG data (R= .99, and .95 respectively for elbow flexors and R=.96 and .95 for leg extensors). However, the IEMG versus torque relationship for all of the contractions of the elbow flexors was found to be only generally linear with a high variability between subjects, and the reliability of test-retest slope coefficients was moderate. The leg extensors in contrast demonstrated both high linearity and high test-retest reliability for slope coefficients.

The literature shows that the Cybex II+ has been used in research to test isometric contractions. It has been proven to be both reliable and valid for isometric and isokinetic contractions and will therefore be used in this study.
Speech Intensity

Speech intensity arises from both the amount of energy provided by the lungs, as well as how much movement occurs at the level of the vocal cords. The intensity values for speech range from that of soft conversational volume at 50 dB SPL to that of loud conversational volume at 80 dB SPL for a distance of one yard. The average for normal conversational volume is approximately 65 dB SPL which varies from one yard to one meter depending on the source (Webster, 1978).

Specific intensity levels can result in reflex responses. For example, the startle reflex which is elicited at 85 dB SPL (M. Arsenault, personal communication, June 26, 1995) can cause measurable alterations in muscle tension, respiration, heart rate, and blood pressure, as well as changes in peripheral circulation and gastric motility (Johansson et al., 1983). Also, broadband noise which is essentially speech, elicits the acoustic reflex at a mean of 71.7 dB SPL in those younger than 30 years of age (Wilson, 1981). The acoustic reflex is a reflex in which the middle ear muscles contract in response to loud sounds producing a damping effect on the entering sound waves to prevent potential hearing damage.

Based on a review of the literature and a personal communication (M. Arsenault, June 26, 1995), the average intensities that will be used in this study are 64 dBA for all instructions, 53 dBA for low intensity commands, and 75 dBA for the high intensity commands. All of the above intensities fall below the threshold for the startle reflex.
Hypothesis

The hypothesis of this study is as follows: the maximum torque of the triceps brachii isometric muscle contraction will increase with an increase in the intensity of a voice command in healthy subjects between 18-30 years of age.
CHAPTER 3

Methodology

Design

The design implemented in this study was a within-series design with an ABAB format. The subjects were given a practice session in which the commands were read by the researcher so they would become familiar with the equipment and recorded commands that would follow. The practice session took into account any learning effects. Then tape recorded commands were issued. A set of instructions, always given at normal conversational volume preceded each set of commands (Appendix A). One set of commands (1A) was given at below normal conversational volume, with a second set of commands (1B) at above normal. The sequence of commands was repeated (2A) and (2B). The commands directed the subjects to contract the triceps brachii muscle. Subjects were randomly assigned by computer generated random numbers to one of two groups (ABAB or BABA).

Design Benefits

This design resembles a study by Johansson et al (1983). The advantage of this design was that the effects of the intervention could be evaluated twice. If the effects were established during the two separate implementation phases it would give increased evidence that the resultant change was due to the intervention. This provided a means for controlling internal validity as it allowed for the collection of similar results within a
second trial period. Another advantage is the random assignment of subjects to different groups to assess order effects.

**Design Limitations**

A possible limitation of this within-series design was that the behavior of increased force of muscle contraction had to be able to revert back to baseline force levels in order to provide definitive evidence for the hypothesis. However, even if the target behavior did not return to baseline values, it would still be possible to establish a relationship because the use of a second baseline and second intervention would provide a means for establishing an association. Another limitation arose from the inability to control individual intrinsic variables such as motivation, affect, and attention.

Foreseen limitations controlled within this study were fatigue effects, and extraneous noise. The element of fatigue was controlled by providing a 60 second rest period after each muscle contraction. Extraneous noise was reduced by testing subjects in an isolated environment. The only audio variable altered was that of volume.

**Study Site**

The study took place in Grand Valley State University's (G.V.S.U.) Human Performance Lab. The lab was reserved for use during data collection and prior approval was obtained from James R. Scott (Associate Professor of Physical Education and coordinator for Human Performance Lab). Approval for this study was obtained from Grand Valley State University's Human Subjects Review Board.
Subjects

The subjects were recruited by convenience and were healthy individuals ranging from 18-30 years of age. The convenience sample was recruited by posting signs on the G.V.S.U. campus, by placing flyers in physical therapy students' mail boxes, and by verbal recruitment. The term healthy indicated that each subject had no evidence of underlying pathologies as determined by a thorough screening of the subjects through both written questionnaire (Appendix B) and physical examination (Appendix C). The physical examination consisted of manual muscle testing of subjects' myotomes C1-T1, and range of motion testing to subjects' neck, shoulders, elbows, wrists, and fingers. In order to participate in this study, subjects had to answer no to all questions on the subject questionnaire, had to have ROM within 5-7 degrees of normal based on Kendall's (1993) norms, and strength of at least four plus out of five as defined by Kendall. The ROM was visually observed and goniometrically measured only if it appeared questionable.

Torque Measurement Instrument

The instrument used in this study was the Cybex II+. The Cybex II+ is an isokinetic dynamometer that has the capability to quantitatively measure several aspects of muscle performance. These aspects of muscle performance include the measurement of strength, torque, power, power endurance, isometric time-rate of torque development, peak torque and fatigue. The aspect of muscle performance that this study was concerned with was peak torque (the maximum torque production), which was measured in foot-pounds via the Cybex II+ chart recorder. The method for positioning and stabilization of
the subjects was according to the recommendations stated in the handbook for using
Cybex II and U.B.X.T. (Upper Body Exercise and Testing Table).

**Audio Instrumentation**

The auditory equipment consisted of a cassette tape player that was placed one
meter behind the subject, and at the level of the subject's head. The instructions and
commands for the subject to contract the triceps brachii were prerecorded on to two tapes,
one with the high volume command issued first, and a second with the low volume
command issued first. The instructions and commands for each tape were quantified
using a Quest Electronics Model 2700 Sound Level Meter SPL A scale in fast mode (to
measure the peak volume). Volumes of commands were measured at their peaks as
human speech has inherent fluctuations in intensity. The measurements with the sound
level meter were made one meter from the speaker of the cassette player in a position that
the subject's head would occupy, with the subject absent. The microphone of the sound
level meter was calibrated using a Quest Electronics CA 12 B Calibrator. The
instructions were delivered in a normal conversational volume peaking at 64 dB SPL A
scale. The high volume commands peaked at an average of 75 dB SPL A scale, and the
low volume commands peaked at an average of 53 dB SPL A scale.

**Procedure**

The procedure consisted of subject screening, an initial trial period and an actual
testing period. Informed consent was obtained from each subject prior to subject
screening period (Appendix D). Prior to the initial testing period, the Cybex II+
isokinetic dynamometer was calibrated according to the manufacturer's protocol
The Cybex II+ dynamometer was set at a speed of zero degrees per second in order to ensure that a voluntary isometric contraction was recorded. All testing was performed using the subject’s dominant arm. The subject was placed in the supine position with his/her hips and knees flexed and feet comfortably resting on a footrest attachment. The subject's shoulder was placed in 90 degrees of abduction and neutral rotation. The elbow was positioned at 90 degrees flexion and the subject's forearm and wrist were placed at zero degrees as measured by a goniometer. The initial trial period involved a live provision of the directions to the subjects as found in Appendix A. The subjects then performed a one trial practice contraction of the triceps brachii. The actual testing proceeded in the following manner. One of two prerecorded tapes, either the ABAB or BABA sequence, was inserted into a tape player. Each trial involved a set of instructions, a set of commands, and a 60 second rest period. The tape recorded version contained substartle commands set 22 dB apart. The high volume commands had an average peak of 75 dB SPL A scale and the low volume commands had an average peak of 53 dB SPL A scale. During the actual testing period the tape recorder was placed one meter from the subject. The muscle torque of the triceps brachii was recorded by the Cybex II + chart recorder once the contraction had been initiated by the commands. Data was collected from each volunteer during one session that lasted approximately 30 minutes. The primary investigators collected data over a nonconsecutive five day period.

**Data Analysis**

The statistical procedures used in this study were descriptive statistics and a series of analysis of covariance (ANCOVA) and analysis of variance (ANOVA) models for an
unbalanced incomplete-block crossover trial design. The predictor variables of interest were volume, exercise, age, height, weight, and gender. The treatment variable was volume and the remaining variables were covariates (extraneous variables that potentially may influence the treatment variable). Because of the sample limitations, covariates were examined singly and in combination using hierarchical models.
CHAPTER 4
Results/Data Analysis

Subject Characteristics

A total of 46 subjects participated in the study; however, seven subjects were excluded. Reasons for exclusion include testing errors on the part of the researchers, procedural errors by subjects, and ages that exceeded the 18-30 year limit. Data was analyzed for 39 subjects, 23 females and 16 males. Twelve females and five males were in the ABAB group, while eleven females and eleven males were in the BABA group (Table 1).

<table>
<thead>
<tr>
<th>Gender</th>
<th>ABAB</th>
<th>BABA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>12/17</td>
<td>11/22</td>
<td>23/39</td>
</tr>
<tr>
<td>Male</td>
<td>5/17</td>
<td>11/22</td>
<td>16/39</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>22</td>
<td>39</td>
</tr>
</tbody>
</table>

The mean age of the group was 23.8 (23.3 for females and 24.5 for males). The average weight for females was 134.8 pounds and for males 169.7 pounds. The mean heights for males and females was 71.1 inches and 65.2 inches respectively (Table 2, 3, and 4). In the category of regular exercise, 81.3 percent of the males were involved in regular exercise compared to only 69.6 percent of the females. The ratio of physical therapy students to non-physical therapy students was comparable between the two groups (Table 5, 6, and 7).
### Table 2  
**Entire Group Subject Demographics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^a)</td>
<td>23.7949</td>
<td>2.6772</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>Height(^b)</td>
<td>67.6282</td>
<td>3.6719</td>
<td>61</td>
<td>76</td>
</tr>
<tr>
<td>Weight(^c)</td>
<td>149.1026</td>
<td>28.1283</td>
<td>105</td>
<td>245</td>
</tr>
</tbody>
</table>

\(^a=\text{years}\) \(^b=\text{inches}\) \(^c=\text{pounds}\)

### Table 3  
**Female Subject Demographics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^a)</td>
<td>23.3043</td>
<td>2.4943</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Height(^b)</td>
<td>65.1956</td>
<td>2.2650</td>
<td>61</td>
<td>70</td>
</tr>
<tr>
<td>Weight(^c)</td>
<td>134.7826</td>
<td>19.3601</td>
<td>105</td>
<td>185</td>
</tr>
</tbody>
</table>

\(^a=\text{years}\) \(^b=\text{inches}\) \(^c=\text{pounds}\)

### Table 4  
**Male Subject Demographics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^a)</td>
<td>24.5000</td>
<td>2.8519</td>
<td>19</td>
<td>29</td>
</tr>
<tr>
<td>Height(^b)</td>
<td>71.1250</td>
<td>2.1252</td>
<td>67</td>
<td>76</td>
</tr>
<tr>
<td>Weight(^c)</td>
<td>169.6875</td>
<td>26.2341</td>
<td>130</td>
<td>245</td>
</tr>
</tbody>
</table>

\(^a=\text{years}\) \(^b=\text{inches}\) \(^c=\text{pounds}\)
### Table 5
**Entire Group Subject Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise-Yes</td>
<td>29</td>
<td>74.36%</td>
</tr>
<tr>
<td>Exercise-No</td>
<td>10</td>
<td>25.64%</td>
</tr>
<tr>
<td>PT Student-Yes</td>
<td>17</td>
<td>43.59%</td>
</tr>
<tr>
<td>PT Student-No</td>
<td>22</td>
<td>56.41%</td>
</tr>
<tr>
<td>ABAB</td>
<td>17</td>
<td>43.59%</td>
</tr>
<tr>
<td>BABA</td>
<td>22</td>
<td>56.41%</td>
</tr>
</tbody>
</table>

### Table 6
**Female Subject Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise-Yes</td>
<td>16</td>
<td>69.60%</td>
</tr>
<tr>
<td>Exercise-No</td>
<td>7</td>
<td>30.40%</td>
</tr>
<tr>
<td>PT Student-Yes</td>
<td>10</td>
<td>43.50%</td>
</tr>
<tr>
<td>PT Student-No</td>
<td>13</td>
<td>56.50%</td>
</tr>
<tr>
<td>ABAB</td>
<td>12</td>
<td>52.20%</td>
</tr>
<tr>
<td>BABA</td>
<td>11</td>
<td>47.80%</td>
</tr>
</tbody>
</table>

### Table 7
**Male Subject Characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise-Yes</td>
<td>13</td>
<td>81.30%</td>
</tr>
<tr>
<td>Exercise-No</td>
<td>3</td>
<td>18.80%</td>
</tr>
<tr>
<td>PT Student-Yes</td>
<td>7</td>
<td>43.80%</td>
</tr>
<tr>
<td>PT Student-No</td>
<td>9</td>
<td>56.30%</td>
</tr>
<tr>
<td>ABAB</td>
<td>5</td>
<td>68.80%</td>
</tr>
<tr>
<td>BABA</td>
<td>11</td>
<td>31.30%</td>
</tr>
</tbody>
</table>
Techniques

The statistical design used in this study was an unbalanced incomplete-block crossover trial. The mean torques of each group are listed in tables 8 and 9. Group BABA was found to produce a higher mean torque per trial than group ABAB.

Table 8

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>17</td>
<td>22.0588</td>
<td>13.2168</td>
</tr>
<tr>
<td>Trial 2</td>
<td>17</td>
<td>22.5882</td>
<td>15.6167</td>
</tr>
<tr>
<td>Trial 3</td>
<td>17</td>
<td>23.3529</td>
<td>17.3158</td>
</tr>
<tr>
<td>Trial 4</td>
<td>17</td>
<td>22.3824</td>
<td>16.9370</td>
</tr>
</tbody>
</table>

Table 9

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>22</td>
<td>32.3636</td>
<td>20.7009</td>
</tr>
<tr>
<td>Trial 2</td>
<td>22</td>
<td>33.7955</td>
<td>21.5846</td>
</tr>
<tr>
<td>Trial 3</td>
<td>22</td>
<td>32.4091</td>
<td>21.5730</td>
</tr>
<tr>
<td>Trial 4</td>
<td>22</td>
<td>32.0000</td>
<td>21.9783</td>
</tr>
</tbody>
</table>

Four components were used as predictors in the ANOVA models. These components were order (BABA or ABAB), person nested within order (i.e. a measure of torque variation from person to person within the same order), trial (1-2-3-4 i.e. the time effect), and treatment (i.e. high or low volume). These four components made up the most basic model which had an $R^2$ equal to 0.979 (Table 10). An $R^2$ equal to one reflects a model that perfectly interprets the data.
Table 10
ANOVA # 1

<table>
<thead>
<tr>
<th>Source</th>
<th>d.f.</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order</td>
<td>1</td>
<td>3871.62</td>
<td>3871.62</td>
<td>354.1</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Order (Person)</td>
<td>37</td>
<td>53576.85</td>
<td>1448.02</td>
<td>132.4</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Trial</td>
<td>1</td>
<td>1.07</td>
<td>1.07</td>
<td>0.1</td>
<td>0.7549</td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>6.04</td>
<td>6.02</td>
<td>0.6</td>
<td>0.4589</td>
</tr>
<tr>
<td>Model</td>
<td>40</td>
<td>57455.3</td>
<td>1436.4</td>
<td>131.4</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Error</td>
<td>115</td>
<td>1257.4</td>
<td>10.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total-corrected</td>
<td>155</td>
<td>58712.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a d.f. = degrees of freedom, b SS = sum of squares, c MS = mean square
* P<.05

A preliminary analysis revealed that the components of order and person nested within order were significant, while trial and treatment were not. To further investigate the significance of these two components, other models that included the difference in gender distribution between the two groups was used. Further analysis indicated that gender could account for the significance of order and person nested within order found in the initial model (Table 11). No other components were significant, although order continues to approach significance. The R² of this model was 0.588.
Hypothesis/Research Question

The question of interest was: does the intensity of voice command have an effect on the maximum torque production of a subsequent isometric muscle contraction in healthy individuals between the ages of 18-30 years old? It was hypothesized that the maximum torque of the triceps brachii isometric muscle contraction would increase with an increase in the intensity of a voice command in healthy subjects between 18-30 years of age. There was not enough evidence to reject the null hypothesis of no volume effect as the p-value was not significant.
CHAPTER 5
Discussion & Implications

Discussion of Findings

The results of this study indicate that the volume and peak torque relationship was not significant. Several reasons for this lack of significance could exist. Possible reasons include motivational effort of subjects, lack of a substantial peak volume for the high commands, and small sample sizes secondary to gender distribution between groups.

Motivation is an important factor affecting motor performance and has been defined as an inner urge that prompts one to action (Crutchfield & Barnes, 1993). One’s level of motivation directly influences how well one performs (the higher the motivation, the greater the performance). If the subjects in this study were highly motivated, they would have performed maximally during all trials. This maximum performance effort may have resulted in a ceiling effect, and hence, no volume effect.

Our high volume commands peaked at 75 dB SPL A scale, our low volume commands peaked at 53 dB SPL A scale, and the normal conversational baseline volume was 65 dB SPL A scale. Whereas, Johansson et al. (1983) incorporated a normal conversational baseline volume of 78 dBA, and high and low commands of 88 dBA and 66 dBA respectively. Although the decibel range of 22 was comparable with our study, the Johansson study utilized a high volume command that was greater than ours which could account for the difference in findings between the studies.
Another possible reason for the lack of significance found in our study is the small sample size. The subdivision of our sample size into groups by gender resulted in small sample sizes. When small samples are used, only large differences can be detected. If a larger sample size had been chosen, a significant difference in the treatment variable may have been detected.

**Applications to Practice**

In relation to application to practice, clinical experience suggests that volume does have an effect on muscle performance. The importance of voice intensity has been noted by physical therapists for many years with respect to obtaining optimal motor performance from patients (Umphred & McCormack, 1990). The use of voice level is also a vital component of the PNF approach and many other facilitation techniques. In clinical practice, it is likely that as intensity is varied, tone and pitch are as well, which may make it difficult to be certain which aspect of voice is impacting motor performance. Although the effect of voice intensity on motor output was not supported through our research endeavor, the Johansson et al. (1983) study does indicate that a relationship may exist between volume and torque production. Further research is necessary to support the assumption that this interaction is significant.

**Limitations**

Limitations to our study include: sampling technique, sample size, and recording procedure. The sample was one of convenience. A convenience sample is a nonprobability sampling technique which limited the generalizability of this study. Our sample size was divided on the basis of group and gender. This distribution resulted in
four different groups ranging in size from twelve to five subjects. These small sample sizes may have limited our ability to detect differences. A sophisticated recording procedure was not utilized. Two different tapes were made for each group. Four commands were read for each tape while the volume was varied manually.

**Suggestions for Further Research**

Future research should incorporate the following variations to this study: a probability sampling technique, a larger more gender equivalent sample size, and a more sophisticated torque measurement instrument and recording procedure. Instructions and commands should have been recorded at the same volume on a single tape. Then the gain should have been adjusted to produce two tapes with different volumes and sequences, thus eliminating the influence of other auditory variables. Future research should be carried out to investigate the level at which volume may impact muscle performance.

**Conclusions**

No significance was found between voice intensity and peak torque. Research in this area is limited, and further studies utilizing our recommendations may give us greater understanding of the complexity of this aspect of motor functioning, and its use in patient care.
Reference List


APPENDIX A

SAMPLE SUBJECT INSTRUCTIONS
VERBATIM INSTRUCTIONS:

INITIAL INSTRUCTIONS: When you hear the commands to push, you are to push as hard as you can against the machine arm as if to straighten your elbow. Do not try to use your whole body—just concentrate on straightening your arm. When the commands stop, relax.

COMMANDS: Push, push, push!

SUBSEQUENT INSTRUCTIONS: Fine. We are going to do the test again. When you hear the commands to push, you are to push as hard as you can against the machine arm to straighten your elbow. Do not try to use your whole body—just concentrate on straightening your arm.

COMMANDS: Push, push, push!
APPENDIX B

SAMPLE SUBJECT QUESTIONNAIRE
SUBJECT QUESTIONNAIRE

NAME: ____________________
AGE: _____
WEIGHT: _____
HEIGHT: _____
SEX (PLEASE CIRCLE): M  F
HANDEDNESS (PLEASE CIRCLE): L  R

HAVE YOU HAD ANY OF THE FOLLOWING: (Circle one)

1. Feeling of dizziness, vertigo, nausea, or nystagmus?  Y  N
2. Any hearing problems?  Y  N
3. Have you ever failed a hearing test?  Y  N
4. Any ear infections in the last month?  Y  N
5. Any cancer, tumor (benign or malignant), or cyst of the ear?  Y  N
6. Any blows to the side of the head within the last month?  Y  N
7. Any history of arthritis, bursitis, joint problem, fracture/dislocation of the neck, shoulders, elbows, wrists, or fingers within the last six months?  Y  N
APPENDIX C

SAMPLE SUBJECT PHYSICAL SCREEN & DATA SHEET
SUBJECT PHYSICAL SCREEN

Name and Random #: ______________________

U.E. ROM:

• FINGERS: ______

• WRIST: ______

• ELBOW: ______

• SHOULDER: ______

• NECK: ______

U.E. STRENGTH:

• C 1-2 (Cervical) ______

• C 3-4 (Upper Trapezius) ______

• C 5 (Deltoid) ______

• C 6 (Biceps) ______

• C 7 (Triceps) ______

• C 8 (Extensor Pollicis Longus) ______

• T 1 (Intercrossei) ______
DATA COLLECTION SHEET

NAME: ______________________  SEX: F  M
DATE: ______________________  HANDEDNESS: R  L
Wt: ________  GROUP: ABAB  BABA
Ht: ________  AGE: ________

Do you participate in upper extremity exercise? Y  N
If yes, what type? ______________________
How many times a week? _________________

MAXIMUM TORQUE PRODUCTION (ft-lbs):

TRIAL #1  __________
TRIAL #2  __________
TRIAL #3  __________
TRIAL #4  __________
APPENDIX D

SAMPLE INFORMED CONSENT FORM
INFORMED CONSENT FORM

I understand that this is a study that involves the effects of verbal commands on muscle performance. This research is being done in order to further the knowledge base of physical therapy, which will improve patient treatment techniques.

I also understand that:

1. Total time commitment will be 45 minutes.
2. I will be placed in a machine that will measure how much torque my elbow muscle is producing.
3. This procedure will begin with an initial trial period in which I will be given live instructions to perform a practice contraction of my elbow muscle.
4. The actual testing period will consist of tape recorded instructions that will be identical to the practice session instructions.

I acknowledge that:

• There is the possibility of mild muscle soreness and muscle fatigue with participation in this study.
• I have the right to withdraw from this study at any time and I will not be penalized for doing so.
• I have the right to obtain full disclosure of information to any questions I may have regarding this study at any time.
• I will play a part in the advancement of physical therapy research by my participation in this study.
• My participation in this study and the resultant outcomes will be used to enhance physical therapy treatment techniques, and thus improve patient care.
• Information obtained regarding my results from the study will remain anonymous to all except the primary investigators. All information regarding personal data will be strictly confidential.

• I should contact Molly Veen (669-4343) or Lisa Marichal (895-9443) in regard to any questions concerning the research, my rights as a subject, or any research related injury.

• I acknowledge that I have read and understand the above information, and that I agree to voluntarily participate in this study.

Participant: ________________________ Witness: ________________________
Date: ___________________________ Date: ___________________________