AN ELECTROMYOGRAPHIC STUDY OF THE EFFECTS OF OVERFLOW AND CUTANEOUS STIMULATION

A THESIS

Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Arts in Occupational
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We hereby recommend that the thesis prepared under our supervision by Jo Ann Arrington entitled AN ELECTROMYOGRAPHIC STUDY OF THE EFFECTS OF OVERFLOW AND CUTANEOUS STIMULATION

be accepted as fulfilling this part of the requirements for the Degree of Master of Arts.

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CHAPTER I

INTRODUCTION

Occupational therapy techniques for central nervous system disorders have incorporated principles of neuromuscular physiology. Knowledge of the developmental sequence, the steps in a sequence, and the components of the patterns have focused the emphasis of treatment on total neuromuscular involvement, not just on strengthening an isolated weak or flaccid muscle. It is known that abnormal patterns often develop not because of direct damage to the muscles themselves but rather from damage to the normal mechanisms by which these muscles are facilitated (Stockmeyer, 1967).

Through the use of EMG, the first signs of muscle action potentials can be monitored so even the slightest responses to facilitation can be observed. This in itself has served to increase the knowledge of neuromuscular involvement.

The neurophysiological approach used by Rood (1962) has been defined as "the activation, facilitation, and inhibition of muscle action, voluntary and involuntary, through the reflect arc." Rood (1962) maintained that treatment or therapy was not just achieving a motor act alone, but rather the application of stimuli to activate a response. This was followed by sensory input from a correct response with additional stimuli given to facilitate or inhibit elements in the pattern (Rood, 1962).

In the clinical treatment of hemiplegia, many occupational therapists use the central nervous system to assist in the treatment by application of the following principles:

1. The central nervous system can redirect an impulse from one side of the body to produce a like response in the other side. This phenomenon is termed bilateral facilitation, overflow, associated movement, or cross exercise (Herring, 1964; Sherrington, 1906; Stockmeyer, 1967; Gregg, Mastellone, and Gersten, 1957).

2. Systematic application of repetitive, resistive exercise to the good musculature remaining in a partially disabled extremity produces reflex activity of functional value in weak or paralyzed muscles (Partridge and Walters, 1959).

3. Stimulation of proprioceptive end organs in the contracting muscles causes cessation or diminution of excitatory impulses along the motor neuron to the antagonistic muscle. This is frequently referred to as "Sherrington's Law of Reciprocal Innervation" (Gregg, Mastellone, and Gersten, 1957).

4. The central nervous system has the ability to summarize. If a stimulus is repeated frequently over a long enough period of time, a movement may be produced. It has

further been observed that overflow appeared and was increased either by increasing the load on the exercised extremity or on the number of repetitions (Herring, 1964).

5. Muscles which are identified as stabilizers or "one joint extensors and limb abductors" are facilitated by rapid brushing and three to five seconds of maintained ice, as both affect the "C" (sensory afferent) size fiber endings. It is these "C" size fiber endings which are believed to discharge into multisynaptic pathways and centers involved in the regulation of posture and motor neuron activity (Stockmeyer, 1967).

The principles have been applied to elicit responses in involved, non-functioning muscles of hemiplegic patients. In most instances, the muscles involved were the wrist extensors. The involved musculature was iced and brushed prior to eccentric contractions being given to the non-involved extremity. As the eccentric contractions to the non-involved extremity were repeated, a faint contraction would be noted in the involved musculature. The patient would be asked to contract the involved musculature following the neuromuscular facilitation and frequently a positive contraction in the involved extremity could be elicited. In the clinical situation, it was difficult to prove the technique hastened rehabilitation.

EMG studies were available which supported the clinical importance of cross exercise, but none was found which would support the technique described above. The present study was designed to determine whether the cutaneous stimulation in the form of icing and brushing would affect the overflow in cross exercise, and if it would increase the amount of EMG activity when the subject was asked to execute a maximum contraction.

Statement of Hypotheses

The hypotheses to be tested were as follows:

I. Cutaneous stimulation in the form of icing and brushing will not increase the amount of EMG activity when the subject executes a maximum eccentric contraction.

II. Cutaneous stimulation in the form of icing and brushing will not alter the overflow pattern to the unexercised muscle on the contralateral arm.

Limitations of the Study

This study was limited to volunteers from The Texas Woman's University. Only women with no known neurological involvements were included. EMG readout was limited to surface electrodes and three monitoring channels on the TECA (TE-4-Electromyograph System).

CHAPTER II

REVIEW OF LITERATURE

Introduction

Review of the literature was directed toward the physiological effects of cutaneous facilitation as presented by Margaret S. Rood and others, the physiological effects of cross exercise, and the physiological effects of fatigue.

The Physiological Effects of Cutaneous Facilitation

Margaret Rood, occupational therapist and physical therapist, derived basic principles for treatment of central nervous system disorders from neurophysiological and developmental literature. The source for her working hypothesis is quoted from Stockmeyer (1967) as follows:

> The α motor neuron remains as the final common pathway; however, its discharge is preceded by γ motor neuron activity which functions to regulate the influences from muscle spindle afferents impinging on the α motor neuron. This feedback from the muscle spindle is of prime therapeutic importance. Since the nature of feedback will be in part determined by the state of the γ motor neurons, external influences which affect the γ system are the concern in the development procedures. γ motor neuron activity alters the bias of spindles, which changes the sensitivity of primary and secondary afferent endings to stretch. Eldred reports that all types of spindle endings have a discharge in response to static length of the muscle; however, the secondary endings which have little

> sensitivity to rapid changes in length appear to be better suited to monitor static length. The primary endings also have a "dynamic component" which signals the rate at which muscle length is changing. With its "static component" as a baseline, change to a longer or shorter length could be registered by the "primary afferent."
>
> Several other factors must be identified before a working hypothesis can be proposed. The superficial mobilizing muscles have a greater proportion of primary afferent receptors to secondary afferent receptors. Primary afferent discharge has a facilitating effect on the motor neurons of the muscle in which they lie and that of the muscle's synergist, and has an inhibitory effect on the motor neuron on antagonistic flexors.
>
> Muscles which have been identified as stabilizers of one joint extensors and limb abductors contribute maintenance of posture, maintained contaction static responses for regulation of mobility, etc. The receptors which facilitate stabilizers are influenced by continuous uninterrupted stimuli and have an indirect effect on tonic α motor neurons via polysynaptic pathways.

Stockmeyer (1967) states the rationale for fast brushing is as follows. The rapidly moving brush (a battery powered mixer with the stirrer replaced with a soft brush) influences the skin receptors by stimulating the non-specific endings with "C" size fibers. Since the repeated stimulus provided by the rapidly moving brush stimulates "C" fibers rather than "A" fibers, the discharges are believed to go into multisynaptic pathways and centers involved in the regulation of posture and α motor neuron activity. If skin and muscle are functionally related (Ingram, 1960), then the fast brushing may allow for the build up of central facilitation from non-specific sensory stimulation.

Ice applications are also applied for their effect on the "C" size fibers (Stockmeyer, 1967). An application of ice for a period of 3-5 seconds between 12°C and 17°C is used. Prolonged ice can have an inhibiting effect (Stockmeyer, 1967). Clendenin and Szumski (1971) found that brief cutaneous applications of ice over the biceps brachii in which an isolated motor unit had been trained elicited facilitation of both background activity and spontaneous activation of the trained single motor units. Wolf and Basmajian (1973) confirmed this study.

Physiological Effects of Cross Exercise

Basmajian (1974) states that the hypothesis that there is transfer activity to the contralateral limb during the prescribed exercise on one side has frequently been postulated, but is now being seriously questioned. The author found in his studies of spastic patients, however, that an exuberant overflow occurred to the opposite limb. Walshe (1923) has written about similar phenomena in hemiplegic patients. Basmajian (1974) concluded that "cross exercise is, at best, of 'dubious value' in normal subjects."

Gregg, Mastellone, and Gersten (1957), in an EMG study on cross exercise involving the biceps brachii, found that overflow to the unexercised, contralateral muscle did not occur during simple, non-resistive exercise during isometric contractions of the biceps brachii but did appear as the exercise stress and the number of repetitions were increased. Overflow invariably appeared first in the opposite triceps brachii and positioning of the unexercised arm or stabilizing with straps did not influence the overflow. The authors stated that a relationship was suggested between the appearance of overflow, movement of a heavy load, and fatigue. Overflow to both the triceps and biceps disappeared if the subject performed a maximum isometric contraction or observed a two-minute rest period. However, on resumption of the isokinetic exercise, overflow reappeared with increasing intensity up to its previous maximum (Gregg, Mastellone, and Gersten, 1957).

Partridge (1959) stated the following conclusions from an EMG demonstration of facilitation: (1) systematic application of repetitive, resistive exercise to the good musculature remaining in a partially disabled extremity produces reflex activity of functional value in weak or paralyzed muscles; (2) the indirect training of musculature rendered non-functional from disease or trauma is physiologically sound and psychologically beneficial.

Hellebrandt and Waterland (1962) in their study on indirect learning, concluded that observation of the activity alone affected performance. They also reported that cross education was demonstrable in individual cases but not in all cases. Daily progressive resistive exercise with full mobilization of the joint to the exercised extremity yielded the best results; but in extreme overloading, mounting stress and an expanding irradiation of the movement pattern could be observed.

The Physiological Effects of Fatigue

Fatigue can be of several different types, such as emotional, "general," central nervous system, and peripheral nervous system. The present discussion is confined to fatigue of strenuous effort and its relationship to EMG.

Basmajian (1974) reported that Seyffarth found the increasing fatigue of prolonged voluntary periodical contractions were accompanied by a reduction of potentials. There was diminution and variation in amplitude of the size of the motor unit potential. Lundervold reported that hand muscles when fatigued recruited muscles not considered essential to the particular movement (Basmajian, 1974).

Eason (1960), in an EMG study on the forearm, reported that during sustained contractions recorded with surface electrodes over the flexor digitorum superficialis, the amplitude of the integrated EMG increased progressively with time in both active and passive muscles. He suggested that additional motor units were progressively recruited to compensate for the loss in contractility due to impairment of fatigued units. The action units summate with those of already active units to more than offset the drop in the impaired units. The author also reported that surface EMGs progressively increased in amplitude with continuous or repeated contractions not associated with fatigue. The rate of increase was proportional to the magnitude of contraction.

CHAPTER III

METHODOLOGY

Plan of Procedure

Gregg, Mastellone, and Gersten (1957) established that cross exercise with maximum resistance given to the agonist of one muscle group causes tension in the musculature of both the agonist and the antagonist of the musculature on the opposite side. The purpose of this study was to evaluate the effects of cross exercise following cutaneous stimulation as a therapeutic technique. The hypotheses to be tested were as follows:

I. Cutaneous stimulation in the form of icing and brushing will not increase the amount of EMG activity when the subject executes a maximum eccentric contraction.

II. Cutaneous stimulation in the form of icing and brushing will not alter the overflow pattern to the unexercised muscle on the contralateral arm.

The hypotheses were tested by each subject completing the following three trials with a rest period of five minutes between each trial.

Trial I. Purpose: to evaluate an eccentric contraction of the right wrist.

Procedure: 3-second eccentric contraction of the right wrist with EMG direct readout.

Trial II. Purpose: to study the effects of overflow to the unexercised right wrist from the exercised left wrist.

Procedure: a 3-second eccentric contraction of the left wrist followed by a 5-second rest. Repeat this procedure nine times and then repeat Trial I.

Trial III. Purpose: to study the effect of overflow with previous cutaneous stimulation.

Procedure: apply ice for 10 seconds to the right extensor group and then brush the right extensor group for 10 seconds. Repeat Trail II and then Trial III.

The Sample

Persons selected for the study were volunteers from the faculty, staff, and student body of The Texas Woman's University. Twenty adult women above the age of eighteen volunteered for the study. Two criteria for inclusion in the study were that the subjects be over eighteen and have no known neurological deficits. Four subjects were used in preliminary testing procedures only. The remaining sixteen comprised the present study. An additional subject with diagnosed cerebral palsy was evaluated but those results were not included in the analysis. Each subject agreed to participate in all testing processes.

The Data Collection

Sixteen adult women were selected as subjects. All were familiarized with the testing process employed. A preliminary investigation established maximum values. Each subject was seated in a straight-back chair with the forearms resting on a plinth. The arms were placed in 80-90 degrees of flexion with slight internal roation of the shoulders. The elbows were between 165-175 degrees of extension. The wrists were in neutral position, palms open and flat on the plinth. This position was chosen in an effort to enhance the extension synergy. All eccentric contractions were started with the wrist in full hyperextension. Recordings were made as the wrist was in eccentric contraction into the neutral position.

The extensor carpi ulnaris, both left and right forearms, and the flexor carpi ulnaris, right forearm, were chosen for study because they can easily be palpated for electrode placement (Brunnstrom, 1966). McFarland, Krusen, and Weathersby (1962) found that during extension of the wrist, the extensors of the wrist worked synchronously: none appeared to be the prime mover. Backdahl and Carlsöö (1961) stated that reciprocal innervation between this extensor and this flexor occurred during stretch.

The skin of each subject was prepared so that the impedance was reduced below 5000 ohms. Bipolar surface electrodes measuring .7 cm in diameter were then filled with electrode paste and firmly attached to the prepared area. Inter-electrode distance was maintained at .1 cm for all placements (Hinson, 1969). The electrode placement for the extensor carpi ulnaris was on the dorsal surface, approximately two inches below the lateral epicondyle of the humerus and in line with the muscle belly. The electrode placement over the flexor carpi ulnaris was on the ventral surface, approximately two inches below the lateral epicondyle of the humerus and in line with the muscle belly. A ground lead was prepared for each pair of electrodes and placed on the dorsal surface about two inches proximal to the carpal area.

A TECA (TE-4 Electromyograph System) multichannel, Fiber optic-writing recorder was used to record the direct muscle potential. The instrument has wide band-pass responses and high sensitivities. The three independent recording channels were each set with a high and low pass of 16 hz and amplification of 200 µv/div.; film speed was set at 25 cm/sec.

The film speed mode was set on continual space so that it could be turned on by a remote digital clock timer. The timer started and stopped with all eccentric contractions to record the amount of time of each contraction and to record the results (Rodriguez and Oester, 1971).

As a pretest standard, each subject was seated in the standardized position. The TECA channel recorder arm was then moved close to the subject to eliminate movement of the electrode wires. The position of the forearms on which the electrodes were placed allowed for minimal movement. The subject was then told to relax, and the channels were checked for quiescence. Next, the subjects were told to gradually build tension in each of the channels to check for responsiveness to the muscle action potentials. The electrodes were not removed until the completion of all three trials. The pretest allowed the subject to become familiar with the EMG equipment with a pretest described by Waterland and Shambes (1969).

An effort was made to replicate the clinical technique, so manual resistance was given. Each eccentric contraction was defined as a maximum effort to resist being pulled from wrist hyperextension into neutral position. Resistance was gradually increased to push the wrist into neutral position. The contraction was held for approximately three seconds.

Trial I was executed by the examiner standing to the right side of the subject and applying resistance with the right hand to the subject's right metacarpal bones. A 3-second eccentric contraction was executed and recorded with a digital timer. The trial was followed by a rest period.

Trial II was executed by the examiner standing to the left side of the subject and applying resistance to the left metacarpal bones. The right extremity was placed in resting position. A 3-second eccentric contraction was executed and recorded with a digital timer. A 5-second rest followed. The contraction-rest periods continued until ten contractions were executed and recorded. Following the completion of the ten contractions, the examiner moved immediately to the right side of the subject and repeated Trial I.

In Trial III, the examiner applied an ice cube contained in a plastic bag to the extensor surface of the right forearm for a period of 10 seconds. The suggested time for icing, according to Stockmeyer (1967), is 3-5 seconds, but the time was increased in the present study because of difficulty of icing around the electrode wires. After the icing, a 10-second rapid brushing was applied to the surface above the same muscle group. When this was completed, the examiner moved immediately to the left side of the subject and the examiner repeated Trial II and then Trial I.

A posttest of the recording electrodes was done by repeating the pretest prior to the removal of the electrodes. Adequate rest was provided between trials to eliminate fatigue factors (de Vries, 1968). The subjects were not verbally motivated and the results of the other subjects' Trials were not discussed.

Analysis of Data

According to Waterland and Shambes (1969), Cavanagh (1974), and Close (1964), no universally approved method of scoring and analyzing EMG data has been established. For the purpose of this study, an attempt of objective analysis was employed to analyze the eccentric contractions of the right extensor carpi ulnaris. The method was devised because it would consider both the frequency and amplitude of a muscle contraction and lend itself well to statistical treatment for interpretive assistance.

The direct EMG recordings were divided into the positive and negative phase to form a baseline. A metric scale was used with a baseline marked with a three-centimeter division, followed by a five-centimeter division. The three-five division was used because visual inspection of the direct recordings revealed that the peak of the EMG data occurred approximately three centimeters from the start of the EMG data and plateaued or diminished beyond eight centimeters.

The five-centimeter division was composed of eight parallel lines above the baseline. Each line was .2 centimeter above the previous line. The numbers recorded for each subject were obtained by counting from the first legible spikes in a 0.2 centimeter division above the baseline and adding to that number the tally of spikes which crossed into each .2 centimeter division above it.

An anlysis of variance, treatment by subjects' design, was used to interpret this data (Bruning and Kintz, 1968).

Analysis of the effect of the overflow was objectively done by comparison of the overflow recorded for the first, fifth, and tenth contraction of each subject. The results were tallied according to the muscle in which the overflow first appeared. Three categories were possible. Overflow could appear first in the extensor carpi ulnaris, the flexor carpi ulnaris, or in both muscles simultaneously. A chi square analysis was used for interpretation of data (Bruning and Kintz, 1968).

CHAPTER IV

RESULTS

The results of the study are presented in terms of each hypothesis.

Results of Hypothesis Number 1

Cutaneous stimulation in the form of icing and brushing will not increase the amount of EMG activity when the subject executes a maximum eccentric contract.

The EMG data were treated by analysis of variance, treatment by subjects' design, and are summarized in Tables 1 through 4. Table 1 shows that a significant difference

TABLE 1

ANALYSIS OF VARIANCE BETWEEN TRIAL I, TRIAL II, AND TRIAL III

Source of Variance	ss	df	ms	f	p
Total	41,838	47	. .	. .	. .
Subjects	26,107	15	. .	. .	. .
Treatments	3,774	22	1887	5	$<.025$*
Error	11,957	32	373		

*Significance = $p < .05$

($p < .025$) appeared among the muscle action potential readings elicited from all three trials. The totals from Trial I, Trail II, and Trial III also indicated progressive increase in muscular activity.

An analysis of variance was then applied to Trial I and Trial II, as indicated in Table 2. A difference ($p < 0.10$) was noted. While not significant, the findings suggested that muscular activity increased with the use of overflow. In reviewing the raw data, all but three of the subjects increased in muscular activity between Trial I and Trail II, but the overflow alone did not elicit muscle action that was significant.

TABLE 2

ANALYSIS OF VARIANCE BETWEEN TRIAL I AND TRIAL II

Source of Variance	ss	df	ms	f	p
Total	18,223	31	. .	. .	
Subjects	8,756	15	. .	. .	
Treatments	1,785	1	1785	3.38	< .10
Error	7,682	15	512		

Table 3 indicates that a difference ($p < 0.20$) between Trial II and Trail III existed. In reviewing the raw data, ten of the sixteen subjects increased in muscle activity; however, the increase was not sufficient to conclude that icing and brushing alone increased muscle activity to any great extent.

TABLE 3

ANALYSIS OF VARIANCE BETWEEN TRIAL II AND TRIAL III

Source of Variance	ss	df	ms	f	p
Total	34,790	31	. .	. .	
Subjects	10,008	15	. .	. .	
Treatments	306	1	306	0.1876	< 0.20
Error	24,476	15	1631		

Table 4 shows the results of the analysis of variance between Trial I, an eccentric contraction, and Trial III, an eccentric contraction after overflow and previous cutaneous stimulation. A significant difference ($p < .025$) was found to

TABLE 4

ANALYSIS OF VARIANCE BETWEEN TRIAL I AND TRIAL III

Source of Variance	ss	df	ms	f	p
Total	28,776	31	. .	. .	
Subjects	17,219	15	. .	. .	
Treatments	3,570	1	3570	6.710	< .025
Error	7,987	15	532		

exist, indicating that overflow in combination with icing and brushing did significantly increase the amount of muscle action in the unexercised contralateral extremity.

Results of Hypothesis Number 2

Cutaneous stimulation in the form of icing and brushing will alter the overflow pattern and increase the overflow to the unexercised contralateral muscle.

The analysis of the effects of icing and brushing on the overflow pattern were treated by the complex chi square analysis shown in Tables 5, 6, and 7. In Table 5, the first occurrence of overflow in Trial II was compared with that of Trial III. A probability level of 0.25 was obtained. While the overflow pattern was increased to the extensor carpi ulnaris, the probability was 0.75 that this increase was real.

TABLE 5

COMPLEX CHI SQUARE ANALYSIS BETWEEN TRIAL II AND TRIAL III

First Occurrence of Overflow	Flexor Carpi Ulnaris	Extensor Carpi Ulnaris	Both
Overflow without cutaneous stimulation	3	44	15
Overflow with cutaneous stimulation	2	52	8

$x^2=2$ df=2 $p < .25$

Table 6 shows the results based on an assumption that the first occurrence of overflow occurred by chance alone. The distribution then would have been equal for all three categories. Table 6 displays the analysis of this assumption compared to the first occurrence of overflow without cutaneous facilitation. A probability level of .01 was achieved.

TABLE 6

COMPLEX CHI SQUARE ANALYSIS BETWEEN TRIAL II AND CHANCE DISTRIBUTION

First Occurrence of Overflow	Flexor Carpi Ulnaris	Extensor Carpi Ulnaris	Both
Overflow without cutaneous facilitation	3	44	15
Chance distribution	20.66	20.66	20.66

x^2=22.48 df=2 $p < .01$

Table 7 displays the analysis of this assumption as compared to the first occurrence of overflow with cutaneous facilitation. Tables 6 and 7 show that overflow did not occur by chance. They also show that the significance level was increased with cutaneous facilitation, which would indicate that a definite overflow pattern existed.

TABLE 7

COMPLEX CHI SQUARE ANALYSIS BETWEEN TRIAL III AND CHANCE DISTRIBUTION

First Occurrence of Overflow	Flexor Carpi Ulnaris	Extensor Carpi Ulnaris	Both
Overflow with cutaneous stimulation	2	52	8
Chance distribution	20.66	20.66	20.66

$x^2=34.36$ df=2 $p < .0075$

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

The purpose of the present study was to evaluate, through electromyography, the neurophysiological technique of cutaneous stimulation and its influence on facilitation of muscle action potentials. Gregg, Mastellone, and Gersten (1957), in an EMG study of cross exercise involving the biceps brachii, reported that overflow appeared first in the opposite triceps. Therefore, it was a concern of the study to establish the overflow pattern to the contralateral muscles during eccentric contractions of the extensor carpi ulnaris, and then to establish if previous cutaneous facilitation would alter the pattern. It is important for a therapist to know the overflow pattern to avoid facilitation of the wrong muscle group.

The following hypotheses were investigated:

I. Cutaneous stimulation in the form of icing and brushing will not increase the amount of EMG activity when the subject executes a maximum eccentric contraction.

II. Cutaneous stimulation in the form of icing and brushing will not alter the overflow pattern to the unexercised muscle on the contralateral arm.

Subjects with no known neurological involvements were used in the study to establish a data base for subsequent studies on subjects with known neuromuscular involvement.

Sixteen subjects were asked to execute three trials, with an adequate rest period between trials. Trial I was designed to assess the muscle action potential of an eccentric contraction; Trial II, to assess the effects of overflow; and Trial III, to assess the effects of overflow with previous cutaneous facilitation. The scores of the eccentric contractions were tallied and treated with analysis of variance. The frequencies of the first appearance of overflow were tallied and treated with the complex chi square. These instruments were used to determine whether (1) there was an actual increase in muscle action potential following overflow, (2) there was an actual increase in the muscle action potential if the agonist were iced and brushed prior to overflow, (3) there was an overflow pattern to the agonist in the contralateral arm, and (4) there was a change in the overflow pattern to the agonist of the contralateral arm with icing and brushing.

Conclusions

Results of the investigation indicated the following: (1) a significant difference appeared in the muscle action potential of the agonist on the contralateral arm when a maximum eccentric contraction was compared with a maximum eccentric contraction following overflow with prior cutaneous facilitation; (2) while not significant, the findings suggested that overflow increased the muscle action potential in the agonist on the contralateral arm; (3) icing and brushing alone increased the muscle action potential but only in combination with overflow was the increase in muscle action potential significant. These findings would lead to the rejection of the first hypothesis.

The results of the findings on the first occurrence of overflow followed the same trend as that of the eccentric contraction. They indicated the following: (1) while the icing and brushing increased the first occurrence of overflow to the extensor carpi ulnaris, it was not significant when compared to that of overflow alone; (2) results, when compared to a hypothetical distribution by chance, showed that the overflow to the extensor carpi ulnaris was significant ($p < .01$); overflow with prior cutaneous facilitation was significant ($p < .0075$). These findings would lead to the rejection of the second hypothesis.

Recommendations for Further Study

The first recommendation for further study would be to replicate this study and acquire direct readouts on the flexor and extensor muscles of the exercised arm as well as the unexercised arm. This would allow the examiner to compare the overflow to the antagonist on the contralateral arm with the amount of tension created in the antagonist of the exercised arm. The use of an integrator in combination with the EMG data would facilitate analysis. The use of a motion picture camera could record the exact movement.

Another recommendation would be to repeat the procedure but alter the time-lapse between the facilitation and the maximum eccentric contraction to determine the length of time of the influence of facilitation.

Once the entire data base was established, it would be of interest to therapists involved with neuromuscular disorders to evaluate this technique with different patient categories. The data from normal subjects would help establish a standard with which the findings might be compared.

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APPENDIX

PERMISSION FORM

I, ______________________________, do willingly volunteer to participate as a subject in the research project entitled "An Electromyographic Analysis of Overflow With and Without Previous Cutaneous Stimulation." I understand and accept any and all responsibility for my participation in the above experiment and also understand that I may withdraw from this research at any time. I further state and affirm that I do not consider my rights as a human being to be infringed upon in any way.

date______________________ signed________________________

date______________________ signed________________________

RAW SCORES

Sum of the EMG Readouts by Trials

Subjects	Trial I	Trial II	Trial III
1	70	150	138
2	55	73	44
3	72	85	113
4	77	74	80
5	73	116	146
6	52	24	35
7	104	69	92
8	66	116	130
9	97	100	143
10	71	106	91
11	91	95	96
12	82	95	143
13	82	107	94
14	69	76	58
15	69	77	55
16	45	51	55

Analysis of Variance: Treatments by Subjects or Repeated Measures, Design. Three Variables: Trial I, Trial II, Trial III

Source of Variance	ss	df	ms	f	p
Total	41,838	47	. .	. .	. .
Subjects	26,107	15	. .	. .	. .
Treatments	3,774	2	1887	5	$<.025$
Error	11,957	32	373		