AD-A063 017 ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MASS F/G 5/10
ELECTROMYOGRAPHIC ASSESSMENT DURING ISOKINETIC EXERCISE IN WOME--ETC(U)
JUN 78 A J LLOYD, P D ALLEN, M G COTE

UNCLASSIFIED USARIEM-T-3/78 NL

| OF |
AD
A063017

END
DATE
FILMED
3-79
DDC

REPORT NO T 3/78

ELECTROMYOGRAPHIC ASSESSMENT DURING ISOKINETIC EXERCISE IN WOMEN

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

June 1978

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: T 3/78	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Electromyographic Assessment during Isokinetic Exercise in Women[1,2,3]	5. TYPE OF REPORT & PERIOD COVERED: Exercise Physiology Division Technical Report.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Andree J. Lloyd, Paul D. Allen and Marc G. Cote	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: USA Rsch Inst of Env Med, Natick, MA 01760	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 3E762777A845
11. CONTROLLING OFFICE NAME AND ADDRESS: USA Med Rsch and Dev Cmd, Ft. Detrick, Frederick, MD 21701	12. REPORT DATE: June 1978
	13. NUMBER OF PAGES: 11
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): USARIEM-T-3/78	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report): DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED	18p.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report): NA	
18. SUPPLEMENTARY NOTES: To be published as a USARIEM Report	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number): electromyography, isokinetic exercise, muscle strength, muscle action potentials, physical training	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Electromyographic (EMG) recordings were made during the assessment of arm strength and endurance of an isokinetic exercise in 25 high school women participating in a study designed to evaluate the response of young women to a male military training program. Force and EMG records were obtained during maximum voluntary contractions at isokinetic speeds of 5 and 15 RPM; and during a 30 sec isokinetic endurance trial at 15 RPM. The results indicated that, regardless of the type of training, arm strength and endurance improved.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

040 850

Furthermore, force increase was accompanied by a significant decrease in EMG activity of the dominant muscles. The results suggested that training facilitated arm strength and endurance through an ability to minimize muscle activity. Type of training regimen was not as important as routine participation in exercise.

Approved for public release;
distribution unlimited.

AD_____

TECHNICAL REPORT
NO. T 3/78

ELECTROMYOGRAPHIC ASSESSMENT DURING ISOKINETIC EXERCISE IN WOMEN

by

Andree J. Lloyd, Paul D. Allen and Marc G. Cote

Project Reference:
3E762777A845

Study Reference:
PH-7-76

June 1978

US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

Natick, Massachusetts 01760

FOOTNOTE

This work was conducted while the principal author was assigned to Letterman Army Institute of Research, Presidio of San Francisco, California.

ABSTRACT

Electromyographic (EMG) recordings were made during the assessment of arm strength and endurance of an isokinetic exercise in 25 high school women participating in a study designed to evaluate the response of young women to a male military training program. Force and EMG records were obtained during maximum voluntary contractions at isokinetic speeds of 5 and 15 RPM; and during a 30 sec isokinetic endurance trial at 15 RPM. The results indicated that, regardless of the type of training, arm strength and endurance improved. Furthermore, force increase was accompanied by a significant decrease in EMG activity of the dominant muscles. The results suggested that training facilitated arm strength and endurance through an ability to minimize muscle activity. Type of training regimen was not as important as routine participation in exercise.

INTRODUCTION

The electromyogram (EMG) has been incorporated in studies of human physical performance as a representational measure of neuromuscular activity. Utilizing surface electrodes placed over the contracting muscle, a composite record of the activity of numerous motor units can be obtained which represents activity throughout the muscle (2). A number of studies have demonstrated consistent relationships between performance measures of tension, strength and endurance, and changes in integrated EMG activity (1,2,3,4,11). Voor and Lloyd (8) compared the increase in integrated EMG amplitudes during a maximum subjective endurance of a submaximum isometric force between male and female participants. The average strength difference of approximately 55 percent between the two groups for an elbow flexion (mean of 29.5 kg for males vs 16.2 kg for females) was reflected in an equivalent difference in average EMG amplitude. Lowered values for the females continued throughout the endurance session. Utilizing relative strengths, there was no difference between the groups in maximum subjective endurance times. This data not only indicated a significantly lower level of arm strength in females when compared to males, but also suggested that other factors, central in nature, played a greater role in the female performance than in the males. Eason (3) discussed a cortical control factor over muscle activity which was reflected in increased EMG amplitude levels. The concept of increased synchronization of motor unit activity and a resulting over-utilization of muscles to perform a task was supported by the results of later studies (9,12). Lloyd further demonstrated this effect when EMG activity was significantly reduced by subjects using an auditory feedback of EMG signals with no change in endurance (5). Training effects and the influence of competition were also demonstrated to influence the relationship between EMG amplitude and maximum endurance (6,10). In the later study, endurance increased only when EMG amplitudes were reduced.

In preparation for the first class of female cadets to enter the U.S. Military Academy, a study was carried out to evaluate the response of young women to men's training programs and training procedures utilized at the Academy. As part of this study, a measure of EMG activity was incorporated during the pre-and post-training sessions which would facilitate the interpretation of potential changes in strength and endurance. Recordings were made during the assessment of strength and endurance during an isokinetic exercise.

The primary objectives were twofold: (a) To assess the effects of training on isokinetic strength and endurance during elbow flexion and extension; and (b) to evaluate the influence of training on the relationship of EMG activity to strength and endurance measures.

METHODS

Experimental Design

Sixty women students (16-18 years of age) from two local high schools in the West Point, NY area volunteered to participate. In compliance with Army Human Use regulations, a full briefing was given to all of the volunteers and their parents with signing of consent statements by both parents and volunteers. An extensive physical examination was completed on each volunteer prior to the commencement of the testing and training.

Testing consisted of two sessions, one prior to and one following a seven week training period. Two subjects withdrew from the study during the pre-test segment administered during the two weeks preceding the training. No other subjects were lost for the remainder of the study. A subsample of twenty-five women was selected to participate in the EMG recording portion of the study. Selection was based on the availability of time to prepare the electrode site without interfering with other testing.

At the conclusion of the pre-test, the participants were randomly assigned to one of three training groups: (1) control, (2) strength, or (3) reveille training. Following the seven weeks of training, the three groups were immediately retested (post-testing).

Procedure

After informing the subject of the general nature of the experimental procedure, the areas of skin over the center of the long heads of the biceps and triceps were prepared by scrubbing the skin with a surgical sponge and 70% alcohol. A commercial electrolytic cream was then massaged into the prepared areas. Two Beckman silver-silver chloride surface electrodes per muscle were filled with electrolytic cream and subsequently secured to the skin two centimeters apart with adhesive collars. The electrodes were placed longitudinally over the belly of the muscle as determined by palpation. An indifferent electrode was secured onto the right ear lobe. Resistance across the electrodes was measured with a voltmeter and not allowed to exceed 5,000 ohms. Typically the resistance was less than 1,000 ohms.

The subject was positioned supine on a table next to a CYBEX isokinetic system (CYBEX Div, Lumax, Inc., New York City). The CYBEX system is capable of quantifying muscular strength through the range of motion in either isometric or isokinetic contractions during maximal or repeated contractions. The CYBEX torque arm was adjusted to match the length of the human arm, and the axis of rotation of the elbow was aligned with the CYBEX's axis of rotation. A 360° clamp was positioned to surround the styloid processes of the ulna and radius proximal to the carpal bones of the wrist. The CYBEX's speed was adjusted with the subject's arm fully extended and resting on the table. The subject was told to pull "hard and fast, hard as you can" whereupon she contracted her arm to approximately 120° of flexion and back to full extension.

Contractions were conducted at two CYBEX speeds--5 RPM (30°/sec) and 15 RPM (90°/sec). Three isokinetic maximum voluntary contraction trials per CYBEX speed were conducted with a two minute rest interval between each of the dynamic contractions. Following these six trials plus a five minute rest period, a 30 second isokinetic endurance trial (15 RPM) was given where the subject repetitively flexed and extended her arm as hard and as rapidly as she could. The investigators insured that the subject moved her arm through the full range of motion and that she did not lift her left shoulder from the table. Where the need existed, the investigator placed his hand on the subject's left shoulder to restrain any uplifting from the table.

The EMG electrodes were pre-amplified and recorded on a 7-channel FM tape recorder. Channel monitoring outputs of the two EMG signals (flexor and extensor) from the tape recorder were monitored on two channels of an 8-channel pen oscillograph where the signals were further amplified/filtered for visual observation. The force output (pounds) from the CYBEX (DC signal) was interfaced into a

third oscillograph channel. The output of this third channel (CYBEX force) was electrically integrated and recorded on a fourth oscillograph channel. The integrator totalled the work done (dp/dt in foot-pounds/second), a cumulative figure which represents the area under the curves of each repetition per time. Audio comments and an electronic signal marker were recorded onto separate channels of the recorder to assist in the later analysis.

Following the pre-testing, the subjects were randomly assigned to one of three groups: control, reveille, and strength, including the women who participated in the EMG recording during the arm isokinetic testing. The Control group (n=9) maintained their usual life-styles and physical activity and did not participate in a formal experimental training program. The Reveille group (n=8) engaged in a four days a week program of calisthenics and exercises such as running, pushups, situps, etc., comparable to that given to male Military Academy cadets. The Strength group (n=8) participated in a strength training program three days a week. This program consisted of indoor workouts on Nautilus and Universal gym equipment using established weight lifting regimens and techniques in which muscle groups were exercised from the largest to the smallest. Typical exercises in this program were curls, extensions, pressing, etc. All training was under the supervision of physical education trainers.

Following the seven week training period, the groups were retested in the same manner as the pre-test.

Data Reduction

The EMG data, stored on the 7-channel magnetic tape, were digitized by the following procedure. The recorded EMG signals (DC to 200 Hz) were passed through a RMS to DC converter into an integration circuit. The counts were cumulated for continuous 0.25 second intervals throughout the isokinetic exercise and printed. The verified data prints were introduced into the computer through cards and stored for later analysis. The average mean value for the integrated EMG was derived for each complete phase of the isokinetic exercise (i.e., the flexion from full extension to 120° of elbow flexion and the extension to a full extension position) for both muscles. The variations in channel amplifications were cancelled by converting all average EMG amplitude values to the signal input level in microvolts.

The force data which consisted of the integrated force in foot-pound/second were recorded on the pen oscillograph. The total integrated force for each flexion and extension phase of the exercise were manually recorded and stored in the computer for analysis.

Both the integrated force and mean integrated EMG amplitudes were analyzed separately for each condition of the isokinetic exercise, i.e., the flexion and extension phase of the right arm motion. Each set of data was subjected to an analysis of variance to determine if there was any difference among the three training groups (control, reveille, and strength), the three trials (eight trials in the 30 second endurance), and between the pre-and post-training test sessions.

RESULTS

The analysis of variance results indicated that the mean integrated force during the flexion phase of the maximal voluntary contractions (MVC) at 5 RPM

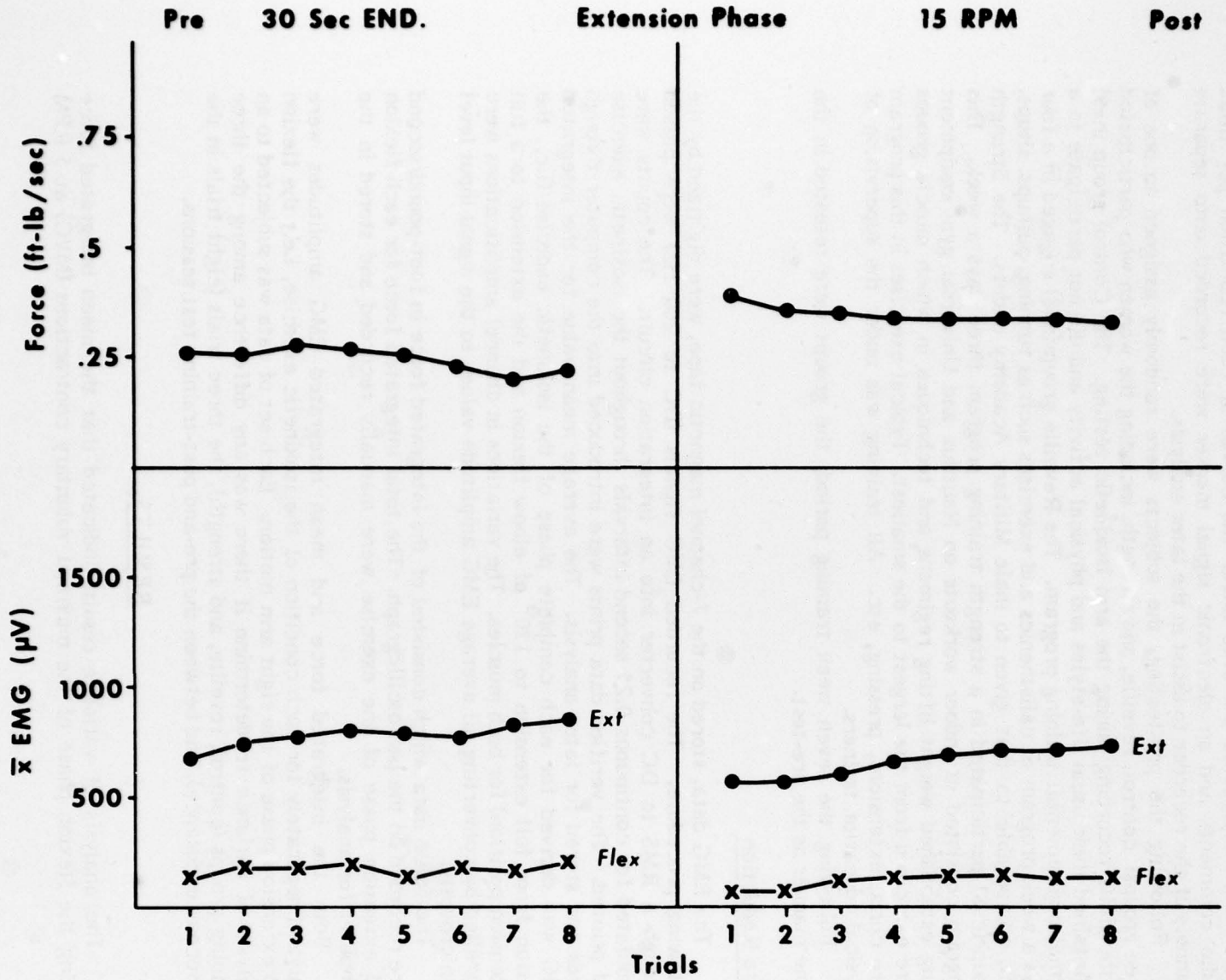

FIG. 1 MEAN INTEGRATED FORCE AND EMG AMPLITUDE REPRESENTING THE THREE GROUPS ACROSS THREE TRIALS FOR THE TWO TEST SESSIONS AT 5 AND 15 RPM SPEEDS. X EMG AMPLITUDES CONSIST OF BOTH MUSCLES SERVING AS DOMINANT AND ANTAGONISTIC FUNCTIONS DURING THE TWO PHASES OF THE ISOKINETIC EXERCISE.

TABLE 1

MEAN INTEGRATED FORCE (ft.lb/sec) FOR 3 MVC TRIALS DURING

THE 5 RPM & 15 RPM FLEXION AND EXTENSION PHASES OF TWO TEST SESSIONS

	Strength (n=8)		Reveille (n=8)		Control (n=9)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
5 RPM						
Flexion	1.07	1.26	1.14	1.47	0.81	1.18
Extension	0.87	1.09	0.83	1.30	0.57	0.97
15 RPM						
Flexion	0.29	0.42	0.32	0.45	0.22	0.37
Extension	0.26	0.37	0.28	0.41	0.17	0.31

significantly increased from the pre- to post-training test session, ($F(1,22) = 28.21$, $p < .05$). The mean differences among the three groups, trials, and interactions were not statistically different (all $p > .05$). Similarly, the mean extension force produced during the same MVC dynamic rate of 5 RPM was increased significantly in the post-training test session when compared to the pre-test mean value, ($F(1,22) = 43.08$, $p < .05$). The mean force values among groups, trials, and the interaction effects were not significantly different (all $p > .05$).

The results of the analysis of variance on the integrated flexion and extension force of the 15 RPM MVC trials produced similar findings. Both the mean flexion and extension integrated forces increased from pre- to post-training sessions (Flexor Force: $F(1,22) = 37.87$, $p < .05$; Extensor Force: $F(1,22) = 37.95$, $p < .05$). There was no significance when groups and trials were compared, nor were any of the interactions significant (all $p > .05$).

Figure 1 and Table 1 depict the mean integrated force data for both the 5 RPM and 15 RPM conditions. Each value represents a combined average of all subjects and for the three MVC trials at each speed of movement. Similarly, the results of the EMG data discussed below were presented in Figure 1 for comparison.

The integrated EMG values were obtained from both the flexor (biceps) and extensor (triceps) muscles during the flexion and extension phase of the isokinetic exercise. Therefore, the dominant and antagonistic actions of these muscles (as reflected in EMG integrated amplitude values) were available. An analysis of variance was done on both the dominant and antagonist muscles of each phase of movement. The analyses on the flexor EMG activity during extension and the extensor EMG activity during flexion for both the 5 RPM and the 15 RPM speeds yielded no significant differences among the gorups, trials, and sessions. None of the interactions were significantly different either (all $p > .05$). However, when the EMG activity of the muscles during dominant activity is considered, the mean EMG activity significantly decreased from the pre- to post-training test session. This was true for the flexor muscle during flexion at a speed of 5 RPM, ($F(1,22) = 80.46$, $p < .05$) and at 15 RPM, ($F(1,22) = 83.89$, $p < .05$), and for the extensor muscle activity during the extension phase at both 5 RPM, ($F(1,22) = 6.95$, $p < .05$), and at 15 RPM, ($F(1,22) = 6.48$, $p < .05$). Similar to the force data, there was no significant difference in mean EMG activity among the groups and trials. None of the interactions were significant (all $p > .05$).

The 30 second endurance test at 15 RPM consisted of a minimum of eight continuous isokinetic maximum voluntary contractions. For analysis purposes, the flexion and extension phases of the eight isokinetic cycles were separated in terms of both the integrated force and EMG.

The results of the analysis on the flexion mean integrated forces indicated that the force produced in the post-training session was significantly greater than in the pre-training test condition, ($F(1,22) = 31.64$, $p < .05$). There was a significant trials effect, ($F(7,154) = 9.34$, $p < .05$), and the sessions by trials interaction was significant, ($F(7,154) = 2.33$, $p < .05$). However, there was no statistically defined difference among the groups ($p < .10$), nor were any of the remaining interactions significant (all $p < .10$).

Similarly, the results of the analysis on the extensor phase of the endurance test indicated that following training, the integrated force increased significantly, ($F(1,22) = 26.11$, $p < .05$). Additionally, there was a significant difference in force across the eight trials, ($F(7,154) = 10.03$, $p < .05$) and in the sessions by trials interaction, ($F(7,154) = 2.53$, $p < .05$). There were no significant differences among

the three groups, nor were any of the remaining interactions significant (all $p > .05$). The mean integrated force for all participants are presented in Figure 2 (flexion) and Figure 3 (extension).

Concomitant with the increased force in the post-training test session there was a significant decrease in the integrated EMG activity of the dominant muscle during both the flexion, ($F(1,22) = 73.29$, $p < .05$), and extension, ($F(1,22) = 5.49$, $p < .05$), phase of the exercise. There was also a significant difference in EMG activity among the eight trials of the dominant muscles, i.e., flexor muscle during the flexion phase, ($F(7,154) = 12.65$, $p < .05$), and extensor muscle during the extension phase, ($F(7,154) = 13.15$, $p < .05$). There was also a significant sessions by trials interaction effect for both the flexion phase, ($F(7,154) = 2.56$, $p < .05$) and the extension phase, ($F(7,154 = 3.17$, p .05). There was no difference among the three groups, nor were any of the remaining interactions significant in these two analyses (all $p < .05$).

Observations made of integrated EMG activity during antagonistic muscle action (i.e., flexor muscle during the extension phase and extensor muscle during the flexion phase of the isokinetic exercise) were analyzed separately by an analysis of variance. With the exception of a significant difference in integrated EMG activity of the extensor muscle during flexion, ($F(7,154 = 2.54$, $p < .05$), there were no significant effects observed. These data for all participants, combining all training groups are depicted in Figures 2 and 3.

DISCUSSION

The high school women who voluntered for this study were athletically active and highly motivated to participate in a physical exercise program. Therefore, even the participants assigned to the control group probably were not sedentary throughout the training period. Support for this assumption was provided by the test battery score similarity among the strength, reveille, and control training groups which measured arm strength and endurance (7). Therefore, the non-significance among the group mean forces was influenced in all likelihood by the selectivity of the participants as an entire group. For the purposes of this study, the selective group was not a negative factor since they are representative of military academy applicants.

Maximum voluntary contractions of an isokinetic arm task improved for the 5 and 15 RPM trials as well as during the 30 second MVC endurance at 15 RPM. Increased force was demonstrated in both the flexor and the extensor muscles. Based on these results, the type of training had no statistical effect on arm strength and endurance. Utilizing the total integrated force for each phase of the isokinetic task, the strength, reveille, and control training groups improved equally. However, the post-test mean force values for each group reflect a trend in favor of the regimented training groups when compared to the control group (Table 1). Furthermore, the post-test means for the reveille group were higher than the strength group. Since the group mean values were not significantly different in the analysis of variance, extreme caution should be taken in attempting to derive any interpretation of this trend.

Competition and other motivational variables have previously been demonstrated to influence physical performance levels and are reflected in EMG measures of neuromuscular activity (6); the relationship between force and EMG amplitude depicted in Figures 1-3 should be noted.

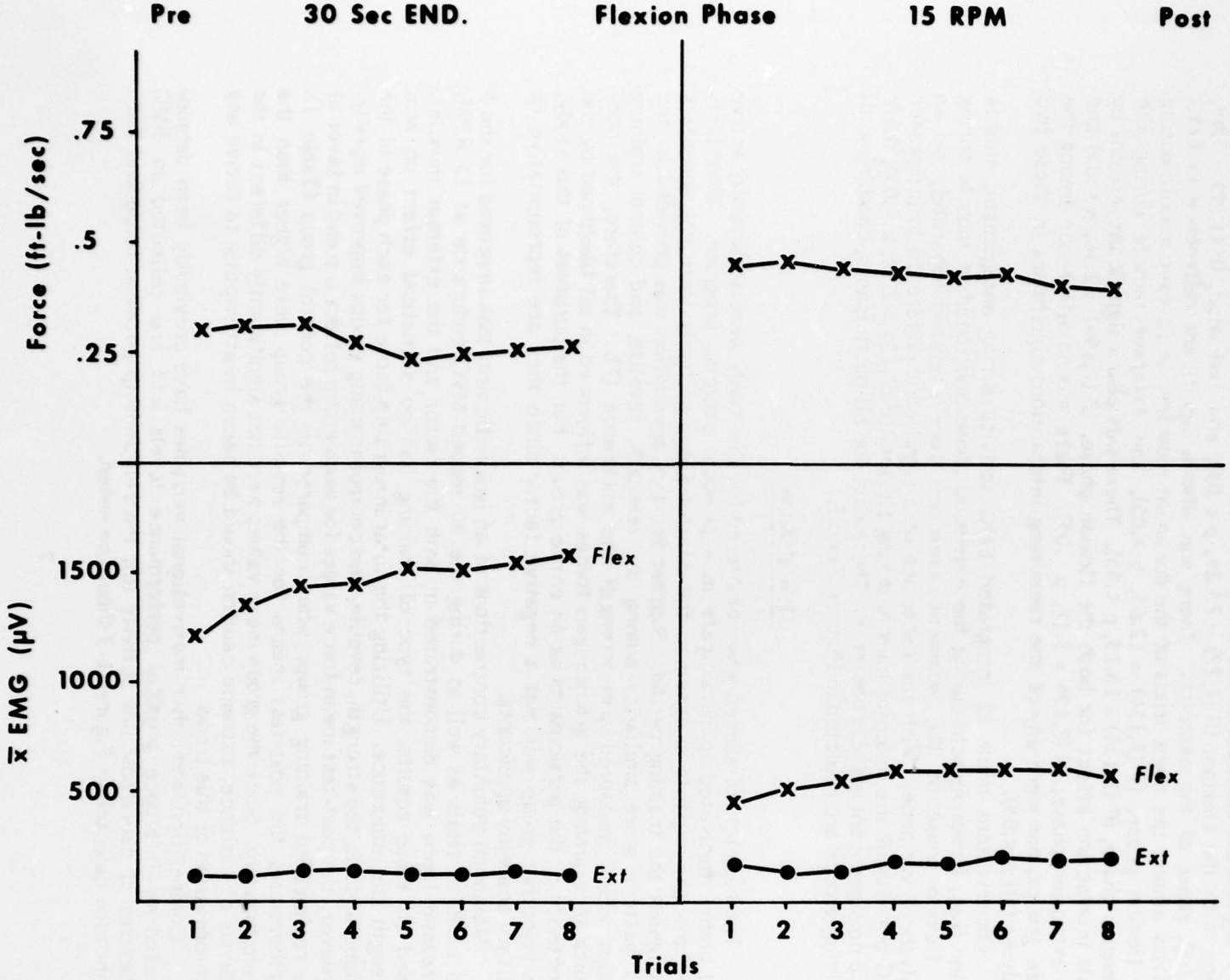

FIG. 2 MEAN INTEGRATED FORCE AND EMG AMPLITUDE FOR THE FLEXION PHASE OF THE 30 SEC MVC ISOKINETIC ENDURANCE TEST. EACH DATA POINT IS THE MEAN VALUE FOR ALL THREE GROUPS OF SUBJECTS. EXTENSOR MUSCLE ACTIVITY REPRESENTS ANTAGONISTIC MUSCLE ACTION.

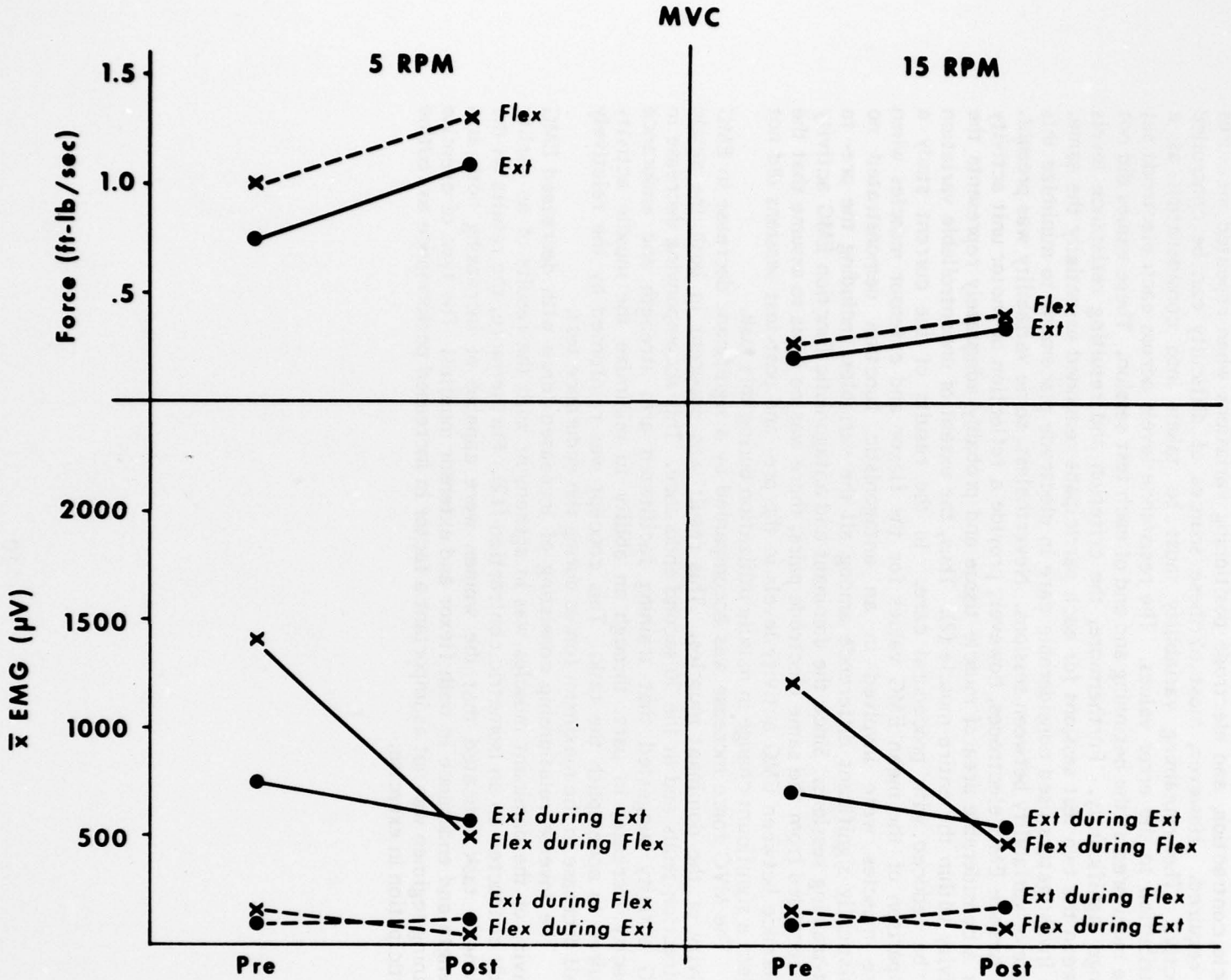

FIG. 3 MEAN INTEGRATED FORCE AND EMG AMPLITUDE FOR THE EXTENSION PHASE OF THE 30 SEC MVC ISOKINETIC ENDURANCE TEST. EACH DATA POINT IS THE MEAN VALUE FOR ALL THREE GROUPS OF SUBJECTS. FLEXOR MUSCLE ACTIVITY REPRESENTS ANTAGONISTIC MUSCLE ACTION.

Surface recordings of electromyographic activity during strenuous exercise tasks are subject to numerous sources of variation, including changes in resistance levels across the recording electrodes, electrode and skin movement during a muscle contraction, and electrode positioning variations when repeated measures are required. However, most of these sources of difficulty can be controlled directly. The remaining variability must be taken into consideration as a contribution to the error values. The resistance levels across each electrode set were monitored at the beginning and end of each test session. These values did not change significantly. Furthermore, the criterion and resulting resistance levels between the two test sessions for each participant remained essentially the same. The investigators used considerable care in electrode placement to minimize this source of variability between sessions. Nevertheless, some variability was present. The surface EMG electrodes, however, provide a reflection of motor unit activity over a considerable area of muscle tissue and probably adequately represents the activity within the entire muscle (2). Thus, the extent of uncontrollable variation can be reduced with procedural care. In the results of the current study a comparison of the mean EMG values for the flexor and extensor muscles when these muscles were involved in an antagonistic function demonstrated no statistically significant difference among all the variables, including the pre- to post-training sessions. Since the dominant and antagonistic function EMG activity was recorded from the same electrode pairs, there was no basis to assume that the difference between EMG activity levels in the pre- and post-test sessions did not reflect a significant change in muscle utilization during this task.

The MVC force increase was accompanied by a significant decrease in EMG activity of the dominant muscles. This result was apparent in both the single contraction trials and in the 30 second endurance. This accompanying decrease in EMG activity suggested that training facilitated arm strength and endurance capacity increase, in part, through an ability to minimize the muscle activity required to accomplish the task. This concept was reinforced by the relatively small decrease in the maximum forces during the endurance test.

The inverse relationship consisting of increased force with decreased EMG activity of the dominant muscles was in agreement with the results of an earlier study conducted on an isometric contraction (12). Furthermore, the results on the isokinetic task indicated that the women were capable of increasing both arm strength and endurance in both flexor and extensor muscles. The type of exercise training regimen was not as important a factor in increased performance as routine participation in exercise.

REFERENCES

1. Bigland, B. & Lippold, O.C.J. Motor unit activity in the voluntary contraction of human muscle. Journal of Physiology (London), 125:322-335, 1954.
2. Close, J.R. Motor Function in the Lower Extremity. Springfield, IL: C. C. Thomas, 1964.
3. Eason, R.G. Electromyographic study of local and generalized muscle impairment. Journal of Applied Physiology, 15:479-482, 1960.
4. Inman, V.T., Ralston, H.J., Saunders, J.B., Feinstein, B. & Wright, Jr. E.W. Relation of human electromyogram to muscular tension. Electroencephalography & Clinical Neurophysiology, 4:187-194, 1952.
5. Lloyd, A.J. Auditory EMG feedback during a sustained submaximum isometric contraction. Research Quarterly, 43:39-46, 1972.
6. Lloyd, A.J. & Voor, J.H. The effect of training on performance efficiency during a competitive isometric exercise. Journal of Motor Behavior, 5:17-24, 1973.
7. Peterson, J.A., Vogel, J.A., Kowal, D.M., & Tomasi, L.F. Project 60: A comparison of two types of physical training programs on the performance of 16-18 year old women. Summary Report, West Point, NY: US Military Academy, May, 1976.
8. Voor, J.H. & Lloyd, A.J. Sex differences in the subjective and electromyographic assessment of isometric muscle contractions. Report No. 849, Fort Knox, KY: US Army Medical Research Laboratory, May, 1970.
9. Voor, J.H., Lloyd, A.J., & Cole, R.J. The influence of competition on the effi ciency of an isometric muscle contraction. Journal of Motor Behavior, 1:210-219, 1969.
10. Voor, J.H. & Lloyd, A.J. Effect of training on the maximum endurance of an isometric muscle contraction. Report No. 941, Fort Knox, KY: US Army Medical Research Laboratory, July, 1971.
11. Wilcot, R.C. & Beenkin, H.G. Relation of integrated surface electromyography and muscle tension. Perceptual & Motor Skills, 7:295-298, 1957.
12. Wilmore, J.H. Influence of motivation on physical work capacity and performance. Journal of Applied Physiology, 24:459-463, 1968.

DISTRIBUTION LIST

5 copies to:

US Army Medical Research and Development Command
Fort Detrick
Frederick, MD 21701

12 copies to:

Defense Documentation Center
ATTN: DDC-TCA
Alexandria, VA 22314

1 copy to:

Superintendent
Academy of Health Sciences, US Army
ATTN: AHS-COM
Fort Sam Houston, TX 78234

1 copy to:

Dir of Biol & Med Sciences Div
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

1 copy to:

CO, Naval Medical R&D Command
National Naval Medical Center
Bethesda, MD 20014

1 copy to:

Dir of Prof Svcs
Office of The Surgeon General
Department of the Air Force
Washington, DC 20314

1 copy to:

Director of Defense Research and Engineering
ATTN: Assistant Director (Environmental and Life Sciences)
Washington, DC 20301