A COMPARISON OF MUSCULAR ACTIVITY LEVELS DURING BENCH PRESSING PERFORMED WITH AN OLYMPIC BAR AND THE UNIVERSAL GYM

by

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ABSTRACT

The purpose of this study was to determine the difference between muscle activity levels during bench pressing with an olympic bar, as compared to bench pressing with a Universal Gym. The muscles monitored were pectoralis major, the anterior head of the deltoid, the triceps, and biceps brachii.

The fourteen subjects were experienced weight trainers with at least two years of training experience. Each subject was required to perform four trials using each method. The order for the eight trials was selected randomly. The load was the same throughout the eight trials and was established at 60% of the subject's most recent single repetition maximum, occurring within the month prior to testing.

Surface electrodes were used to provide electromyographic raw data signals which were amplified through an electroencephalograph unit and then recorded on line by a reel to reel tape recorder. A basic averager program was utilized to provide integrated values in digital form for each of the four muscles monitored from each trial. An initiation signal from a micro pressure switch, and a termination sig-

nal from a photo cell gate were used to frame each trial. This allowed the basic averager program to provide the time duration for each trial measured in one thousandths of a second. The times from the four trials of each bench press method were averaged and the resulting fourteen pairs of averaged time values were tested for significant differences using a Randomized Pair Comparison Design. The resulting t Test statistic was -1.89. This did not reach the critical t values of 2.16 or -2.16 at the .05 level of significance. The result was no significant difference found between the pairs of averaged time values.

The integrated values were then combined with appropriate time factors to provide integrated electromyographic values per unit of time. These four values for each muscle from the four trials using each type of bench press equipment were then averaged. The result was two averaged digital values for each muscle from each subject.

The two averaged values for each subject and each muscle monitored were ranked and a Sign Test was then applied separately to each of the four muscles monitored. The four resulting Sign Test statistics were .286 for the pectoralis major, 2.571 for the anterior head of the deltoid, .286 for the triceps and 2.571 for the biceps brachii. All of these statistical values were less than the critical chi square value of 3.84 at the .05 level of significance. The result was no significant differences found for any of the muscles monitored with respect to their activity levels between the two methods of bench pressing studied.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure

Chapter I

THE PROBLEM

1.1 INTRODUCTION

The early progress of training techniques found in the field of weight training was often based on each participant's practise of the trial and error method. For obvious reasons, this process was long, tedious and certainly questionable. Out of this rather slow march forward, certain exercises and movements gained acceptance within the weight training community as effective methods of training various parts of the musculature.

When active scientific research addressed the area of weight training, it was generally agreed that bench pressing is a movement involving the pectoralis major, deltoid and triceps (Hoffman, 1961; Homola, 1968; Leighton, 1961; and O'Shea, 1969). Extensive research has been conducted to determine the most efficient training programs using this same movement to achieve maximal strength and muscle hypertrophy for the muscles involved (Berger, 1962, 1967; O'Shea, 1966). However, as the activity pattern of this muscular involvement has not been assessed, this has left a wide gap in the literature.

The introduction of various weight training devices which presume to simulate the observable movements of bench pressing with a free bar, has only served to widen the gap in the literature. This gap occurred since not all these devices may produce the same effect upon the musculature as produced while bench pressing with a free bar.

Dynacam, Nautilus and Universal Gym all produce devices which visually simulate bench pressing with a free bar, but all share one obvious difference from bench pressing with a free bar: each device provides a guided path for the load being lifted. Bench pressing with a free bar places all mechanical guidance requirements on the musculature. This difference in guidance may result in different muscle activity levels as a function of the guidance requirements demanded by the method of bench pressing with a free bar and bench pressing through a guided path.

The results of a study which compared the above mentioned bench press methods would have application for both the weight training participant and the academic. The obvious benefit to the participant is the better understanding of the comparative muscular involvement of each method, and therefore, a more knowledgeable base from which to draw for appropriate equipment selection. The academic gain is that an electromyographic study of bench pressing adds to the understanding of muscular activity levels during specific co-ordinated movements under high load conditions.

1.2 STATEMENT OF THE PROBLEM

The purpose of this study was to determine the differences, if any, between muscle activity levels in bench pressing with an olympic bar (an example of bench pressing with a free bar), as compared to bench pressing with a Universal Gym (a device which visually simulates bench pressing with a free bar). Specifically, the total muscular electrical activity per unit of time was compared over the entire vertical displacement of the load for each bench pressing method studied. The muscles monitored were pectoralis major, the anterior head of the deltoid, the triceps and biceps brachii.

1.3 HYPOTHESIS

It was hypothesized that the differing balance requirements of a guided versus a non-guided path during two similar prone bench press methods would have no effect on muscular involvement and therefore, there would not be any significant differences in the muscular electrical activity per unit of time for each muscle monitored.

1.4 SCOPE OF THE STUDY

The study used fourteen (14) male subjects, ranging in age from nineteen to twenty-six years old. All subjects possessed no medical history regarding problems with the upper limbs. Each subject had at least two years of experience on each piece of equipment. Subjects were required to attend one test session. Each subject's most recent single repetition maximum was established via questions regarding their previous month's training program. The subject was required to press 60% of this single repetition maximum, a typical training level (Hoffman, 1961), during each of the eight trials.

The four muscles monitored were pectoralis major, the anterior head of the deltoid, the triceps and the biceps brachii. The selection of the first three muscles was based on acceptance that all are prime movers during the bench press (Hoffman, 1961). The selection of the biceps brachii arises from the observation that this muscle is an active shoulder stabilizer during movements of the humerus (Slaughter, 1959), as occurs during bench pressing.

1.5 LIMITATIONS

The small sample size of this study was unavoidable due to the small population as defined in the previous section of this paper. The result of this sample size was a reduction in the power of the test and therefore an increase in the probability of committing a Type II error. This could have resulted in a failure to reject the null hypothesis when it was not true.

Musculature such as the trapezius and the serratus anterior, known synergists during the anatomical movements involved with bench pressing (Rasch and Burke, 1974), was excluded as these were not mentioned in the weight training literature with respect to bench pressing (Hoffman, 1961; Homola, 1968; Leighton, 1961; O'Shea, 1969). The assessment of their involvement may have added to the understanding of balance requirements during the two methods of bench pressing monitored in this study.

1.6 DEFINITIONS OF TERMINOLOGY

The following terms were used in the text as defined here:

Full-wave rectification: the absolute value of displacement from the base line. The resulting value represents both the electrical interference monitored by the positive and the negative electrodes.

Load: the total weight displaced vertically, measured in pounds. This was either the weight of the olympic bar and attached plates, or the weight attached to the handles of the Universal Gym bench press station.

Olympic Bar: a six foot long, flexible, round metal bar with a gnarled grip surface. The diameter of the bar is one inch. The collars at each end are 2.5 inches in diameter. (A diagram of an olympic bar may be found in Appendix A)

Repetition: the act of lowering the load from a position of full elbow extension to a position of touching, but not resting, on the mid-point of the sternum and then upward vertical displacement of the load back to a position at which the elbows are in full extension.

Set: a specific number of repetitions performed by a participant.

Trial: the act of vertically displacing the load from a stationary position of touching, but not resting, on the mid-point of the sternum to a position at which the elbows are in full extension. This act was performed as rapidly as possible by each subject.

Universal Gym Bench Press Station: a machine which utilizes a second degree lever action and allows a participant to simulate the actions of bench pressing as defined under the term repetition. (A diagram of a Universal Gym Bench Press Station may be found in Appendix A)

Chapter II

REVIEW OF THE LITERATURE

2.1 INTRODUCTION

This chapter presents a review of literature related to the study of methods of prone bench pressing. The chapter is divided into the following sections: authoritative opinion concerning musculature involvement, functions of related musculature, factors affecting the interpretation of integrated electromyograms, and the rationale for selection of electromyographic equipment.

2.2 AUTHORITATIVE OPINION CONCERNING MUSCULATURE INVOLVEMENT

It is generally accepted that bench pressing requires the active concentric involvement of the pectoralis major, deltoid and triceps. Authors such as Homola (1968), Leighton (1961) and O'Shea (1969) indicated this involvement when they prescribed bench pressing as an effective method of exercising these same muscles. This approach is also in agreement with the guide to weight training published by the A.A.H.P.E.R. in 1962.

The first attempt to suggest the relative involvement of these muscles came when Hoffman (1961) stated that the pectoralis major, deltoid and triceps are all prime movers during the bench press. In 1975, Rosentswieg, Hinson and Bourgregnon completed an electromyographic study of isokinetic bench pressing. The high activity levels of the pectoralis major, deltoid and triceps monitored during this study of isokinetic bench pressing lent credence to Hoffman's earlier statements. In addition, the biceps brachii was chosen because of its effect as a shoulder stabilizer during the observed movement.

In Hinson's 1969 study of pushups, the pectoralis major, deltoid and triceps were found to be the most active muscles monitored. This activity, and the direct similarity of joint actions between pushups and bench pressing would seem to support the opinions of the aforementioned authors concerning the musculature involvement of bench pressing.

2.3 FUNCTIONS OF RELATED MUSCULATURE

In an electromyographic study of the musculature of the upper limb, Scheving and Pauly (1959) noted activity from the pectoralis major during both flexion and adduction of the humerus. That indicated that the activity levels monitored increased as opposition to the movements was applied. During flexion of the humerus, the clavicular head of the pectoralis major was found to elicit the greater activity levels, while the sternal head was most active during adduction of the humerus. These findings support those of the earlier studies of Sigerseth and McCloy (1956) and Yamshon (1949) and helped to form a strong basis for the statements of Hoffman (1961) concerning the pectoralis major as one of the prime movers during the performance of the bench press.

Several studies such as those by Sigerseth and McCloy (1956), Slaughter (1959) and Yamshon (1949) have established the deltoid as being active during movements of the upper limb. These investigators have concluded that the anterior, medial and posterior heads of the deltoid were active as both prime movers and stabilizers of the humerus and the shoulder joint. Scheving and Pauly (1959) concurred with these findings and further stated that the three individual heads of the deltoid are most active during movements of the humerus in their particular line of pull. These same researchers emphasized this finding when they indicated that the anterior head of the deltoid is most active during flexion of the humerus. This movement has already been established as an integral part of the performance of bench pressing. The same relative importance of this muscle to the completion of the similar movement of pushups was exhibited by Hinson (1969) when she found the anterior head of the deltoid to illicit the greatest action potentials of all the muscles monitored during the performance of pushups.

During a study of extension of the elbow joint, Pauly <u>et al</u>. (1967) determined that only the medial head of the triceps was active when zero resistance was applied. These same investigators further stated that during resisted extension, which occurs during the performance of the movements of bench pressing, the participation of the remaining two heads of the triceps brachii commenced and increased with increments of the resistance. These findings supported those of Travill (1962), who conducted similar electromyographic studies. Both of these studies went on to agree with Scheving and Pauly (1959) that all three heads of the triceps were active during rapid flexion of the humerus at the shoulder joint and further concluded that this activity represented a stabilizing effect at this joint.

During further electromyographic studies of elbow extension, Barnett (1955) noted activity from all three heads of the triceps muscle. This investigator indicated that the action potentials were high magnitude and that they were elicited only during rapid resisted elbow extension as occurs during the performance of bench pressing.

Slaughter (1959) found that during electromyographic studies of biarticular muscles of the upper limb the biceps brachii was active when flexion or extension of the humerus occurred at the shoulder joint. He went on to conclude that this activity only occurred as the joint structure approached full extension. He then concluded that this activity was a preventative reflex measure against ligamentous injuries at the elbow joint.

2.4 FACTORS AFFECTING THE INTERPRETATION OF INTEGRATED ELECTROMYOGRAMS

Early studies by researchers such as Inman *et al.* (1952) and Lippold (1952) investigated the possible relationship of integrated electromyograms to the physical factors of human muscle. Lippold stated that a linear relationship existed between integrated electromyograms and the tension of a voluntary isometric contraction. Inman *et al.* echoed this commect but was unable to demonstrate a similar relationship while a muscle was allowed to change its length or during dynamic contractions.

In 1954, Bigland and Lippold while studying isotonic contractions found that during these contractions the integrated action potentials were directly proportional to the tension produced by the voluntary contracting muscle. These authors concluded their study by suggesting that tension, velocity and integrated electromyograms provide a composite measure of the number of active fibers and their frequency of firing.

Merton (1954) investigated the effects of fatigue and how it related to the strength of voluntary contractions.

He investigated the strength capabilities of a muscle during the onset of fatigue and determined that the causes of strength decreases are peripheral and exist in the contractile mechanisms of the motor unit. A number of other researchers, such as Edwards and Lippold (1956) and Kuroda et al. (1970) have dealt with the same area of fatigue and elctromyography. Their findings agree that with muscular contractions of average or higher intensity during periods of fatigue, the integrated action potentials increase for the same mechanical work, during periods between fatigue. These authors also agree that this phenomenon is the result of the recruitment of additional motor units which come to the aid of the fatigued motor units. While dealing with the work levels of activity Moritz et al. (1973) suggested non specific submaximal electromyographic levels for use in biomechanical research.

The more recent study by Bousset and Goubel (1973) again approached the area of mechanical work. These researchers found a linear relationship between integrated electromyograms and mechanical work during dynamic contractions and therefore formed the basis for studies such as this. They also indicated that this relationship was valid whether the movement being studied was stopped mechanically or voluntarily, again as is the case in this study of bench pressing.

While providing suggestions for techniques during biomechanical research with electromyography, Cavanagh (1974) noted that the signal amplitude and the relationship between tension and integrated action potentials are dependant upon the separation distances of surface electrodes and their positioning over the muscle in question, and therefore should be standardized.

2.5 RATIONALE FOR SELECTION OF ELECTROMYOGRAPHIC EQUIPMENT

O'Connell and Gardner (1963), while outlining the use of electromyographic equipment and its application to biomechanical research, indicated that surface or subcutaneous electrodes are best adapted to studies of duration and measures of total activity in a muscle.

They went on to say that intramuscular electrodes lend themselves to studies of the activity of single fibers or small groups of fibers within a muscle. These statements were in agreement with a number of authors such as DeVries (1968) and Waterland and Shambes (1969) who also noted that surface electrodes are best applied to the study of gross movements, and a general picture of the whole muscle.

A quantitative comparison of these types of electrodes was made when Bousset and Maton (1972) found a linear relationship between electromyographic records obtained from surface electrodes, during both isometric and dynamic contractions. These researchers went on to suggest that the activity of the muscular fibers near the surface is representative of all fibers involved in the given activity.

These findings further those of Earl, Strong and Thomas (1967) who noted that with the same amplification, surface electrode recordings are of greater amplitude and have a larger number of recorded action potentials than a simultaneous record obtained by a coaxial needle electrode implanted in the same muscle.

Concerning the preparation of subject's skin for application of surface electrodes, authors such as Rosentswieg et al. (1975) stated target figures of 5,000 ohms, but O'Connell and Gardner (1963) suggested that skin resistances of up to 60,000 ohms would still provide for satisfactory and valid electromyographic records.

In 1969, Waterland and Shambes, during a review of electromyographic usages, noted that motor units of human muscle fire with frequencies of between five and one hundred cycles per second. On the basis of these figures, they suggested that electromyographic amplifiers must be capable of responding from 20 to 10,000 cycles per second. Dealing with this same facet, Hall (1970) in a review of electromyographic techniques and equipment, indicated that amplifiers should possess qualities of both a high gain and selectivity for frequencies of between 10 and at least 4,000 hertz.

Commenting on electromyographic recorders, this same author stated that standard pen recorders were generally not suitable for accurate work since the frequency response of the mechanical system was too low to reproduce the electromyographic wave precisely. This echoed the statements of DeVries (1968) and Waterland and Shambes (1969); but the latter authors noted that pen recorders are still economical to run and hard copy tracings are immediately available. These latter considerations would be important only for demonstration purposes.

As alternatives to pen recorders, Hall (1970) suggested the use of an oscilloscope trace or a galvonometer lightbeam system accompanied by permanent photographic records. Still further, Kuroda (1970) indicates excellent results with the use of an FM reel to reel tape recorder and an Ampex SP 300 magnetic tape. The adaptability and increased precision over pen recorders of this system to on line calculations, with the use of a computer, as is the case in this study, would seem obvious.

2.6 SUMMARY

Articles were reviewed that attested to the involvement of the pectoralis major, the anterior head of the deltoid, the triceps and biceps brachii during the performance of bench pressing. The case for studying these muscles was then furthered by noting studies that indicated the involvement of these muscles during anatomical movements associated with bench pressing.

To aid in the interpretation of collected data, various articles were reviewed with respect to the relationships of integrated electromyograms and static and dynamic muscular contractions. Further articles were noted, to help establish an understanding of muscular fatigue. This understanding was utilized in determining the order of trials to negate the effects of fatigue.

Finally, the area of equipment selection was reviewed by noting the various benefits and drawbacks of available equipment as stated by the authors indicated.

Chapter III

PROCEDURES

3.1 INTRODUCTION

This chapter describes the procedures that were used in this study of muscle electrical activity levels during bench pressing with an olympic bar and the Universal Gym. These procedures are presented in the following sections: instrumentation, subjects, experimental method, and data analysis.

3.2 INSTRUMENTATION

A 13 channel Kohden Electroencephalograph (model ME-135D) was used to amplify and monitor electromyographic activity from the muscles monitored. These electromyographic signals were recorded on line by a Crown International 700 series reel to reel tape recorder. Four direct input components by the same manufacturer were utilized to deal with the potentially high frequencies of the signals recorded (Waterland and Shambes, 1969).

Trial duration measures were accomplished with the use of a mechanical micro pressure switch and a photo cell gate switch. The pressure switch was at the level of each subject's mid-sternum and was held closed before the beginning of each trial by the load. The micro pressure switch opened at the initiation of each trial and thus recorded the moment. The photo cell gate switch was located at the highest point of vertical displacement for each subject and with the passage of the load through the gate, the completion of each trial was recorded. Pictures showing the micro pressure switch and the photo cell gate are shown in Appendix B.

Both the micro pressure switch and the photo cell gate were on line with the Crown International 700 Series reel to reel tape recorder, and recorded on a fifth channel using a simple FM component. In addition, a Tektronix 4 channel oscilloscope was utilized to randomly monitor the four electromyographic channels and the trial initiation and termination channel. A flow chart of the recording system is shown in Figure 1.

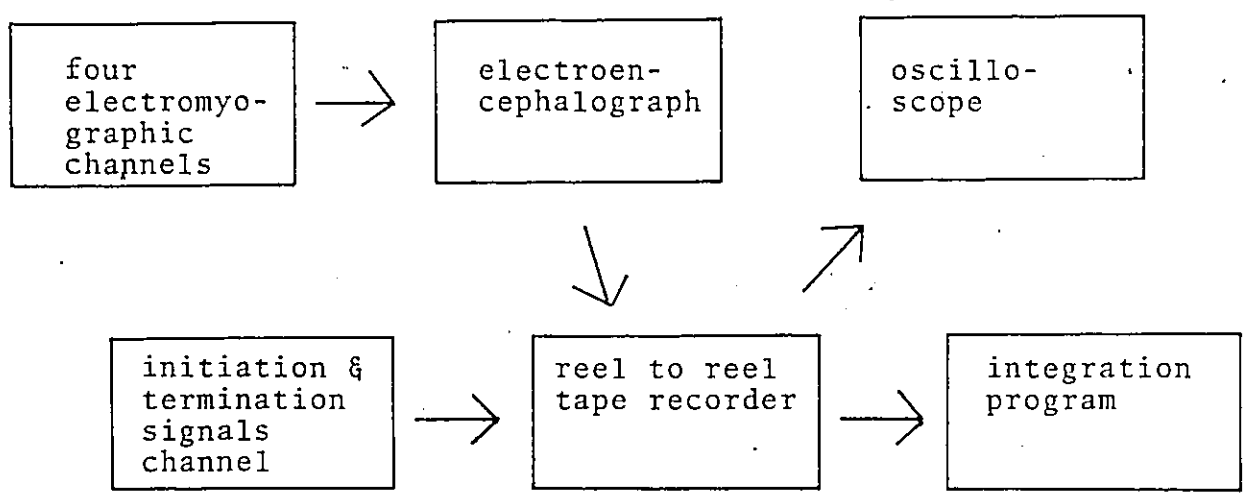


Figure 1: Recording System Components

Integration of the electromyographic recordings was accomplished using a PDP8/E computer on line with the Crown International 700 Series reel to reel tape recorder at a later date. During this integration phase, each channel was played back through the identical direct input component that had been used during the recording of each trial. The same speed was used for recording and playback to ensure accurate time factors.

The program utilized was Digital Equipment Corporation's Lab 8/E Basic Averager Program. A slight modification allowed the program to use the initiation signal from the micro pressure switch and the termination signal from the photo cell gate switch to begin and end each integration job, for each of the electromyographic channels of each trial. This program provided a digital printout of full wave rectified integrated activity levels for each electromyographic channel of each trial. Also provided by the Lab 8/E Basic Averager Program was the time duration of each trial measured in one thousandths of a second. This integrated value was proportional to the area transcribed by the electrical interference pattern of each channel, of each trial.

3.3 SUBJECTS

The subjects (n=14) were male volunteers selected randomly from the Ottawa University football team. The random selection process continued until sufficient subjects had volunteered. They ranged in age from 19 to 26 years old and each possessed no medical history pertaining to the upper torso or the upper limbs. Each subject possessed a minimum of two years weight lifting experience. No subject had participated in strenuous upper torso or upper limb exercise during the twenty-four hours preceding the test session. Historical and anthropometric data was collected from each subject to allow for ranges, means and standard deviations of this material to be tabulated. These data were collected to provide an accurate description of the sample. These data were made up of age, height, weight, years of weight lifting experience, biacromial width and the most recent single repetition bench press using an olympic bar performed within the previous month to the date of testing.

3.4 EXPERIMENTAL METHOD

This section describes the test procedures. All pertinent anthropometric and historical data was collected on a test form from each subject as each test session began. A copy of the test form can be found in Appendix C.1. From these data each subject's test grip width and test load was calculated. The test grip width on the load was standardized at 150% of each subject's biacromial width. This grip width conforms with Hoffman's (1961) recommendation that bench press grip widths should be moderately wider than shoulder width.

The test load for each subject was standardized at 60%

of that subject's most recent single repetition bench press using an olympic bar within the previous month. While these calculations were being made, each subject read and signed a waiver form. A copy of the waiver form can be found in Appendix C.2.

By means of palpation and measurement, the mid-point of each muscle belly to be monitored was located and marked with a black felt pen (O'Connell and Gardner, 1963). This process helped to standardize electrode placement among subjects. The muscle bellies which were marked in this manner were on each subject's right side and were, in order: the pectoralis major, the anterior head of the deltoid, the triceps and biceps brachii. An area with an approximate diameter of three inches surrounding the mid-point of each muscle belly to be monitored, and an area over the subject's right olecranon were prepared for electrode application. This preparation consisted of, in order: washing the area with soap and water, wiping with alcohol, shaving with a safety razor, buffing with 600 sand paper, and wiping with acetone. This preparation was used to lower skin resistance to or below 5,00 ohms; thus enhancing good conductance of the electromyographic signals between the skin and the electrodes. Electrode placement is shown in Appendix D.

Two Beckman Skin Electrodes, each with a diameter of .3 inches, were cleaned with tissue paper, filled with DB Electrode Paste and then affixed to the subject's skin with the use of Hewlett Packard Electrode Adhesive Discs over each muscle belly to be monitored. These electrodes were spaced one inch apart and equidistant from the mid-point of the muscle belly (O'Connell and Gardner, 1963); thus standardizing the sample area between subjects. Also the position of each pair of electrodes was such that a straight line could be drawn on the center of each electrode and the mid-point of the muscle belly and the line would run parallel with the direction of pull of the muscle. Next, a ground or base line electrode was affixed over the subject's right olecranon; a location of minimal electrical activity. At this point, the between electrode resistance was measured for each pair and the preparation measures were repeated, if necessary, until all four between electrode resistance measures were at or below 5,000 ohms. Electrodes were then further anchored with the use of surgical tape to eliminate any movement of the electrodes over the subject's skin.

The subject then performed two warm-up sets to minimize the chance of injurt, at the test grip width. These sets consisted of one set of ten repetitions, at 50% of the test load, on each piece of equipment. During these two sets, each followed by a five minute rest, the monitoring system was checked out and adjustments were made, if necessary. These five minute intervals far exceed the rest periods used to negate fatigue in Merton's (1954) study of strength and fatigue. During the second rest period the micro-pressure switch and photo cell gate switch were positioned for the first trial.

Two axle jacks were used to support the load at the height of each subject's mid-sternum prior to the initiation of each trial. When necessary, either the height of the jacks or that of the prone bench was elevated with the use of pieces of plywood of varying thicknesses. Pictures showing the support of the two load types by the axle jacks can be found in Appendix E. For each trial, prior to the moment of initiation, the load was always considered to be horizontal. Random checks were made with a carpenters spitit level to ensure this horizontal positioning of the load.

After the second five minute rest, each subject performed eight trials. Four of these trials used the Universal Gym bench press station and four used an olympic bar and prone bench. The order of these eight trials was determined by random selection. The load used for each trial was 60% of the most recent single repetition bench press during the month previous to testing, using an olympic bar. Each of these eight trials was separated by an additional five minute rest period, again to negate fatigue, during which the test equipment was repositioned for the next trial, if necessary. At the conclusion of the eight trials for each subject, the electrodes were removed and the areas of electrode application were cleaned and wiped.

3.5 DATA ANALYSIS

Ranges, means and standard deviations were calculated and then tabulated for all historical and anthropometric data collected. These were then discussed with respect to the variables tabulated.

The trial time durations, which were measured in one thousandths of a second, from the four trials using each method of bench pressing, were averaged. This procedure produced a pair of time trial average values for each subject. A Randomized Paired Comparison was utilized to determine if a significant difference existed at the .05 level between the two averaged time trial durations. These values and results were then tabulated and discussed.

The digital values of the four integrated electromyographic signals and trial time duration for each trial, provided by the Lab 8/E Basic Averager Program, were combined to provide four integrated electromyographic signals per unit of time for each trial. The signals from the four trials, using each method of bench pressing, for each muscle monitored were averaged for each subject. These two averaged integrated electromyographic values per unit of time from each muscle monitored for each subject were compared to determine the highest value.

A Sign Test was then utilized four time to determine if a significant difference existed at the .05 level between the two aforementioned averaged values for each muscle monitored. The results of these tests were then tabulated and discussed.

Chapter IV

Results

4.1 INTRODUCTION

This chapter presents the results of this study. It begins with the analysis and discussion of subject data. Descriptions of the integrations of raw signals, data and data translations, along with the analysis of trial time data, are then presented. To conclude the chapter, the analysis of electromyographic data is presented.

4.2 SUBJECT DATA

All historical and anthropometric data collected from the subjects was tabulated with ranges, means and standard deviations, as shown in Table 1.

All subjects were volunteers from a random selection process and were assumed to be representative of weight lifters with at least two years lifting experience with respect to all historical and anthropometric variables.

The range of grip widths used in this study was 22.5 to 25.5 inches with a mean of 24.2 inches and a standard deviation of .8 inches. The range of test loads was 105 pounds to 170 pounds, with a mean of 131.1 pounds and a standard deviation of 19.9 pounds.

TABLE I

Subject Historical and Anthropometric Data

	Range	Mean	Standard Deviation
Age (years)	19-26	22.6	2.2
Lifting Experience (years)	2-9	4.1	2.4
Height (inches)	64.5-73	69.3	2.3
Weight (pounds)	137-219	172.5	23.7
Biacromial Width (inches)	15-17	16.1	.5
Recent Maximum Single Repetition (pounds)	180-280	219.6	32.4

(n=14)

4.3 INTEGRATION OF RAW SIGNALS

Digital Equipment Corporation's Lab 8/E Basic Averager Program was utilized to provide four digital integrated values of full wave rectified activity levels monitored during each trial. Four distinct values were generated from all trials with each value derived from a separate channel.

Each value represented the electrical activity of the muscles monitored from each trial. The pectoralis major was designated channel one; the anterior head of the deltoid as channel two; the triceps as channel three; and the biceps brachii as channel four. In addition, from each trial a digital trial duration time value was generated in one thousandths of a second.

4.4 ANALYSIS OF TRIAL TIME DATA

The four trial time durations from each bench pressing method for each subject were averaged. This produced fourteen pairs of trial time values measured in one thousandths of a second.

Since the original ordering of trials were randomized for each subject, a Randomized Paired Comparison Design was utilized to determine if a significant difference existed between pairs (Box et al., 1978). The design was set as a two tailed test due to the lack of literature concerning this topic and therefore the inability to predict a probable significant difference in one direction. For use with this Randomized Paired Comparison, the critical t value 2.16 was based on a 95% confidence interval with 13 degrees of freedom. The trial time data and pertinent statistical material is shown in Table 2.

TABLE 2

Trial Time Data and Statistical Material

Subject Number	Univ. Gym Method Averaged Time Trial	Univ. Gym Method Standard Deviation	Olympic Bar Method Averaged Time Trial	Olympic Bar Method Standard Deviation	Difference
1	661	36.3	641	312	+20
2	502	32.9	552	68.1	-50
3	857	21.5	756	41.6	+101
4	933	40.6	1065	171.3	-132
5	1417	157	1557	236.3	-140
6	574	32.4	592	76.1	-18
7	910	208.9	731	85.6	+179
8	741	70	962	236.6	-223
9	498	43.9	767	234.4	-269
10	991	39.3	1292	94.8	-301
11	847	82.6	935	80.3	-88
12	998	90.3	938	145.2	+60
13	613	30.8	663	85	-50
14	773	96.2	836	107	-63

(measured in one thousandths of a second)

$\overline{D} = -69.6 \quad S_D = 137.35 \quad S_{\overline{D}} = 36.7$

$\overline{D}$ = the mean of the differences

S_D = the standard deviation of the differences

$S_{\overline{D}}$ = the standard deviation of the mean of the difference

The Randomized Pair Comparison Test statistic was given by:

$$t = \frac{D}{S_D} = \frac{-69.6}{36.7} = -1.89$$

The critical t values of 2.16 or -2.16 were at the .05 level of significance and 13 degrees of freedom. Since critical t values of 2.16 or -2.16 were not reached by the Randomized Pair Comparison Test statistic of -1.89, there was no significant difference found between the pairs of trial time durations.

Although no significant difference was found at the .05 level of significance, it should be noted that an absolute difference of 10% was found between the time duration for the two methods studied. Using this method of comparison, the Averaged Olympic Bar Method time durations were found to be greater than the Averaged Universal Gym Method time durations.

4.5 DATA TRANSLATIONS

From each trial, the four distinct digital integrated values were divided by that trial's time duration. This first translation generated data which was defined as the digital integrated value of full wave rectified activity per second. From each trial, four such values were generated; one from each channel. An example of this initial data translation is shown in Table 3.

TABLE 3

An Example of the First Data Translation

	Raw Data	Translation	Integrated Value Per Second
Channel 1	285469	(÷ 0.635 seconds)	449.6×10^3
Channel 2	923493	(÷ 0.635 seconds)	1454×10^3
Channel 3	243554	(÷ 0.635 seconds)	383.6×10^3
Channel 4	913103	(÷ 0.635 seconds)	1438×10^3

The integrated values per second from each set of four trials using one of the pieces of equipment for each subject was averaged. Therefore, the eight trials resulted in just two average integrated values per second for each of the four channels. One represents the average integrated value per second for each channel during use of the olympic bar, and one represents the average integrated value per second for each channel during use of the Universal Gym bench press station. An example of this second data translation can be found in Table 4.

In Table 5 the average integrated elctromyographic values per second for each muscle for each bench press method is presented.

TABLE 4

An Example of the Second Data Translation

Integrated Value Per Second		Translation	Average Integrated Value Per Second For 4 Trials
Olympic Bar Trials	309.7×10^3 298.1×10^3 253.6×10^3 263×10^3	Averaged	281.1×10^3
Universal Gym Trials	211.6×10^3 249.6×10^3 226.6×10^3 212.3×10^3	Averaged	225.0×10^3

(Subject #12 Channel #1)

TABLE 5

Average Integrated Electromyographic Values Per Second For Each Muscle For Each Bench Press Method

Muscle	Universal Gym Bench Press Station	Olympic Bar Bench Press Method
Pectoralis Major	344.1×10^3	351.5×10^3
Deltoid	1495.3×10^3	1485.8×10^3
Triceps	385.5×10^3	367×10^3
Biceps Brachii	1454.6×10^3	1452.2×10^3

Average Integrated Value Per Second

4.6 ANALYSIS OF ELECTROMYOGRAPHIC DATA

At this point each of the four channels and the respective data generated from each was considered a separate and distinct experiment. The Sign Test was selected as the statistical tool, since the actual electromyographic values could not be compared directly between subjects (Cavanagh, 1974). The use of the Sign Test allowed the electromyographic values to be ranked with respect to the two bench press methods studied for each channel within each subject. This in turn allowed for between subject comparisons for each channel.

For each channel, a separate and distinct Sign Test was performed to determine if a significant difference existed at the .05 level.

In accordance with the Sign Test model, each subject's paired values were compared with respect to the amount of average integrated value per second. One represented the averaged electrical activity during four trials using the Universal Gym Bench Press station, while the other represented the averaged electrical activity during four trials of bench pressing with an olympic bar. For each subject, when the member of the pair with the highest value represented the averaged electrical activity during bench pressing with an olympic bar the comparison was considered positive (+), and when the member of the pair with the highest value represented the averaged electrical activity using the Universal Gym Bench Press station the comparison was considered negative (-). This resulted in a positive (+) or negative (-) value representing each pair comparison for each subject. The number of positive (+) and negative (-) values were then tallied for each channel. The resulting totals per channel are shown in Table 6.

TABLE 6

Comparison Values Per Channel

Channel 1		Channel 2		Channel 3		Channel 4	
(+)	8	(+)	10	(+)	6	(+)	4
(-)	6	(-)	4	(-)	8	(-)	10

Using the comparison values shown in Table 6, the Sign Test statistics were computed for each channel as shown in Table 7.

The resulting Sign Test statistics are shown in Table 8.

TABLE 7

Example of Sign Test Statistics Computations

Value of Comparison	Observed Frequency T_i	Estimated Expected Frequency $E(T_i)$	$T_i-E(T_i)$	$T_i-E(T_i)^2$	$\frac{T_i-E(T_i)^2}{E(T_i)}$
+	10	7	3	9	1.28571
-	4	7	-3	9	1.28571

$$x_s^2 = \sum_{k=1}^{2} \frac{T_i-E(T_i)}{E(T_i)}^2 = 2.57142$$

(Channel 2)

TABLE 8

Sign Test Statistics

Channel 1	Channel 2	Channel 3	Channel 4
$x_s^2 = .286$	$x_s^2 = 2.571$	$x_s^2 = .286$	$x_s^2 = 2.571$

For use with each Sign Test, the critical chi square value of 3.84 was established based on the .05 level of significance and one degree of freedom. In each of the four tests the chi square level of 3.84 was not reached as shown in Table 8. Therefore, in each of the four sign Tests no significant differences were found between the two methods of bench pressing.

Chapter V

DISCUSSION

The probability of a type two error occurring was certainly increased by the small sample size of this study (n=14). This increased chance of having failed to reject the null hypothesis when it was not true demanded comment during interpretation of the data in this study. This limitation was brought on by the inherent low number of subjects available from the limited population as defined by the scope of this study. The requirement of at least two years weight training experience was made to eliminate the possible effects of technique acquisition during testing. Studies such as Hinson's (1969) investigation of the muscular activity during pushups, which used novice subjects, may well have had their results confounded by the effects of learning during testing.

With the high probability of a type two error cited, it was noted that based on the four independant Sign Tests and the use of the chi square value of 3.84 at the 95% limit, no significance was found in each of the four experiments. These results indicated that within the limits of the study, no significant difference between total muscular electrical activity per unit of time monitored over the whole vertical displacement of the load was found for the two methods of bench pressing tested.

An interpretation of these results would suggest that the balance requirements of a non-guided path did not have a significant effect on muscular activity during bench pressing with an olympic bar when compared with bench pressing at the Universal Gym bench press station. From this it had to be assumed that during bench pressing with an olympic bar, which requires path guidance by the subject, either balance was inherent in the muscular activity required to vertically displace the load, or the actual additional activity required to balance the load was low enough in the trained subjects (at least two years of weight lifting experience) to be found not significant by the four Sign Tests applied to this study.

The decision to consider each channel of muscular activity as a separate and independant experiment took its origin from the general agreement that values of integrated muscular activity levels are not comparable between different muscle bellies (O'Connell and Gardner, 1963; Hall, 1970). This same agreement was found to extend to comparisons within single subjects when different muscle bellies were considered.

Furthermore, at no time was any inter-relationship of muscular activity between the four muscle bellies considered to be studied. Each muscle was in fact viewed as a separate entity in this study and the prime interest was to investigate whether any or all of the four muscle bellies under study would be affected significantly by the assumed added requirement of balance during bench pressing with an olympic bar.

From the statistical results of this study, trial time durations between bench press methods were found not to be a significant factor. The two-tailed Randomized Pair Comparison Test at the 95% limit and 13 degrees of freedom found no significant difference between the pairs of averaged trial time durations. The observed 10% absolute difference between trial time durations of the two bench press methods, however, suggests that time may well be a confounding factor in this study. The effect of time trial durations is therefore considered unresolved.

The assumption that the subjects represented weight lifters with at least two years lifting experience and appropriate historical and anthropometric variables, along with the ranges, means and standard deviations of subject ages, heights and biacromial widths, suggested a homogeneous sample. With the small range of 19-26 years for age, 64.5-73 inches for height and 15-17 inches for biacromial width and the means and standard deviations of

22.6 and 2.2, 69.3 and 2.3, and 16.1 and .5 respectively; the sample represented a population of experienced weight lifters of similar age and physical dimensions.

Weight proved to provide the rather large range of 137-219 pounds with a mean of 172.5 pounds and a standard deviation of 23.7. These data certainly indicate a large range of bady weight between subjects. From this, and the similar physical dimensions, it can be assumed that girths about the humerus also could have varied widely and therefore affected electrode sample areas of the upper torso monitored along with the magnitude of electromyographic signals between subjects. This effect was minimized by standardizing electrode placement; but would account for part of the need for between subject studies as this to resort to comparison type statistical models such as the Sign Test.

The most recent single repetition maximum within the month previous to the test also exhibited a large range of 180-280 pounds and a standard deviation of 32.4. Defined as 60% of these maximum single repetition values, the test loads also showed a rather large range of 105-170 pounds and a standard deviation of 19.9. This wide range of test loads suggested that varying amounts of force were used between subjects and therefore an equally wide range of muscle activity was probably monitored (Merton, 1954).

It can be speculated that if the additional effects of guidance requirements during bench pressing with an olympic bar were subtle, then these could have been masked by the inherent large differences of muscle activity between subjects due to the wide range of test loads and the activity levels required to vertically displace them.

The final piece of subject data examined was years of weight lifting experience. The range of 2-9 years and standard deviation of 2.4 represented a diffuse sample with respect to this subject variable. It was initially assumed that with at least two years of weight lifting experience, technique acquisition would have already been completed and the effects of learning and the accompanying possible higher values of guidance requirements related to incomplete technique acquisition would not be present.

If, however, technique acquisition does continue beyond the two year point, then the effects of path guidance while bench pressing with an olympic bar could be dependant on the number of years of lifting experience.

Therefore, the large range of years of lifting experience of the sample in this experiment could have confounded the results.

Chapter VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

This study was designed to determine the differences, if any, between muscle activity levels during bench pressing with an olympic bar, as compared to bench pressing with a Universal Gym. The muscles chosen for this study were the pectoralis major, the anterior head of the deltoid, the triceps and biceps brachii. It was assumed that the only difference between these two techniques of bench pressing was the added requirement of balance while using the olympic bar.

All fourteen subjects possessed at least two years of weight lifting experience and had no history of injuries to the upper torso or limbs. The recording of data was accomplished with the use of an on-line system including an electroencephalograph unit which amplified the raw signal, and a multi-component reel-to-reel tape recorder which was used to record and later feed the amplified data to a computer. The computer was equipped to provide integrated values from the raw data and trial time durations measured in one thousandths of a second.

A Randomized Pair Comparison Test found no significant differences between the pairs of averaged trial time durations at the .05 level and 13 degrees of freedom. However, it was noted that a 10% absolute difference in time trial durations existed.

Data translations were executed to provide ranked values contrasting the two methods of bench pressing. Four separate Sign Tests were employed to determine if significant differences were present between the two methods of bench pressing for each muscle monitored.

For each muscle, no significance was found at the .05 level using a Sign Test.

6.2 CONCLUSIONS

Within the limits of this study and at 60% of single maximum repetitions and among weight trainers with at least two years of experience, the following conclusions were made:

1) The question of whether or not time trial durations had a confounding effect on the results of this study was unresolved.

2) Guidance requirements did not demand significantly higher muscle activity levels during bench pressing with an olympic bar, as compared to bench pressing with a Universal Gym.

6.3 RECOMMENDATIONS

Future studies of the problem investigated by this thesis should attempt to use larger samples than used here (n=14). The increased sample size would increase the power of the test and reduce the high probability of a type two error occuring, as in this study, and therefore increase the external reliability of future studies.

In addition, consideration should be given to both isolating relative years of weight lifting experience and also strength levels as measured by single repetition maximums. Studies which investigated methods of bench pressing by sample groups of specific weight lifting experience duration could determine if the requirements of balance are related to this added criterion. Studies using subjects representing specific strength categories would allow researchers to investigate possible relationships between balance requirements, as reflected by muscle activity levels and test load magnitudes.

Further areas for research would include using test loads higher or lower than the 60% of the subjects' single repetition maximum as used in this study. These studies could determine if the requirements of balance are related to the magnitude of the test loads.

Future studies should also attempt to resolve the question of whether or not differences exist between time trial durations while bench pressing with an olympic bar and the Universal Gym bench press station.

BIBLIOGRAPHY

Barnett, C.H. and D. Harding "The Activity of Antagonist Muscles During Voluntary Movement." Annals of Physical Medicine, 2: 290-293, 1955.

Berger, R. "Effect of Maximal Load For Each of Ten Repetitions on Strength Improvement." Research Quarterly, 36: 715-718, 1967.

Berger, R. "Effect of Varied Weight Training Programs On Strength." Research Quarterly, 33: 168-181, 1962.

Bigland, B. and O.C.J. Lippold "The Relation Between Force, Velocity and Integrated Electrical Activity in Human Muscles." Journal of Physiology, 123: 214-224, 1954.

Bouisset, S. and F. Goubel "Integrated Electromyographical Activity and Muscle Work." Journal of Applied Physiology, 35: 695-702, 1973.

Bouisset, S. and B. Maton "Quantitative Relationship Between Surface Electromyography and Intromyographic Activity In Volintary Movement." American Journal of Physical Medicine, 51: 285-295, 1972.

Box, G.E.P., W.G. Hunter and J.S. Hunter, Statistics For Experimenters. New York: John Wiley and Sons, 1978.

Cavanagh, P. "Electromyography: Its Use and Misuse in Physical Education." J.O.P.H.E.R., 1974

DeVries, H.A. "Efficiency of Electrical Activity As A Physiological Measure of the Functional State of Muscle Tissue." American Journal of Physical Medicine, 47: 10-22, 1968.

Earl, W.D., R. Strong and P.E. Thomas "A Qualitative Analysis of the Specificity of the Surface Electrode in Detecting the Electrical Activity of Muscular Action." Journal of the American Osteopath Association, 66: 1034, 1967.

Edwards, R.G. and O.C.J. Lippold "The Relation Between Force and Integrated Electrical Activity in Fatigued Muscle." Journal of Physiology, 132: 677-681, 1956.

Hall, E. "Electromyographic Techniques: A Review." Physical Therapy, 50: 651-659, 1970.

Hettinger, P.W. Physiology of Strength. Springfield: Thomas Publishing, 1961.

Hinson, M.M. "An Electromyographic Study of the Pushup For Women." Research Quarterly, 40: 305-311, 1969.

Hoffman, B. Weight Training For Athletes. New York: The Ronald Free Press Company, 1961.

Homola, S. Muscle Training In Athletes. West Nyack: Parker Publishing Company, 1968.

Inman, V.T., H.J. Ralston, J.B. Saunders, B. Feinstein and E. W. Wright "Relation of Human Electromyogram to Muscular Tension." Electroencephalography and Clinical Neurophysiology, 4: 187-194, 1952.

Kuroda, E., V. Klissouras and J.H. Milsum "Electrical and Metabolic Activities and Fatigue in Human Isometric Contraction." Journal of Applied Physiology, 29: 358-367, 1970.

Lippold, O.D.J. "The Relation Between Integrated Action Potentials in a Human Muscle and Its Isometric Tension." Journal of Physiology, 117: 492-499, 1952.

Leighton, J. Progressive Weight Training. New York: The Ronald Free Press Company, 1961.

Merton, P.A. "Voluntary Strength and Fatigue." Journal of Physiology, 123: 553-564, 1954.

Marascuilo, L.A., and M. McSweeney, Nonparametric and Distribution Free Methods For the Social Sciences. Monterey: Wadsworth Publishing Company, 1979.

Moritz, U., G. Svantesson and D. Haffajee "A Biomechanical Study of Muscle Torque as Affected by Motor Unit Activity, Length-Tension Relationship and Muscle Force Lever." New Developments In Electromyography and Clinical Neurophysiology, 1: 675-682, 1973.

O'Connell, A.L. and E.B. Gardner "The Use of Electromyography in Kinesiology." Research Quarterly, 34: 166-183, 1963.

O'Shea, J.P. Scientific Principals and Methods of Strength and Fitness. London: Addison-Wesley Publishing Company, 1969.

O'Shea, J.P. "Effects of Selected Weight Training Programs on The Development of Strength and Muscle Hypertrophy." Research Quarterly, 37: 95-102, 1966.

Pauly, J.E., J.L. Rushing and L.E. Scheving "An Electromyographic Study of Some Muscles Crossing the Elbow Joint." Anatomical Record, 159: 47-53, 1967.

Rosentswieg, J., M. Hinson and M. Ridgway "An Electromyographic Comparison of An Isokinetic Bench Press Performed At Three Speeds." Research Quarterly, 46: 471-475, 1975.

Scherrer, J. and A. Bourgreignon "Changes in the Electromyogram Produced By Fatigue in Man." American Journal Of Physical Medicine, 38: 148-158, 1959.

Scheving, L.E. and J.E. Pauly "An Electromyographic Study of Some Muscles Acting on the Upper Extremity of Man." Anatomical Record, 135: 239-245, 1959.

Sigerseth, P.O. and C.H. McCloy "An Electromyographic Study of Selected Muscles Involved in Movements of the Upper Arm at the Scapulo-Humeral Joint. "Research Quarterly, 27:409-417, 1956.

Slaughter, D. "Electromyographic Studies of Arm Movements." Research Quarterly, 30: 326-337, 1959.

Travill, A. "Electromyographic Study of the Extensor Apparatus of the Forearm." Anatomical Record, 144: 373-376, 1962.

Waterland, J.C. and G.M. Shambes "Electromyography: One Link in the Experimental Chain of Kinesiological Research." Physical Therapy, 49: 1351-1356, 1969.

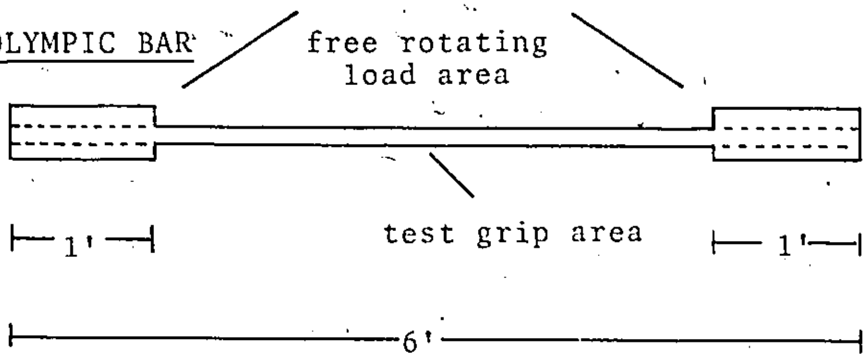
Weight Training in Sports and Physical Education. Washington, D.C.: American Association For Health, Physical Education and Recreation, 1962.

Yamshon, L.J. and W. Bierman "Kinesiologic Electromyography III: The Deltoid." Archives of Physical Medicine, 30: 286-289, 1949.

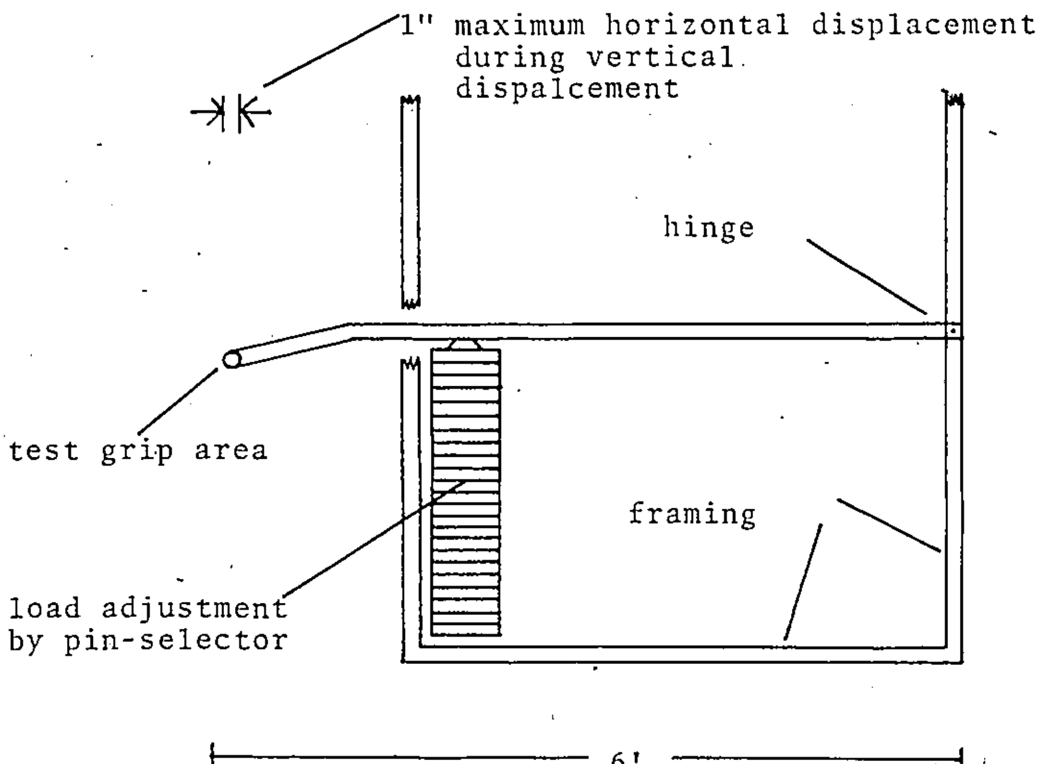
Appendix A

TEST LOADS

A.1 OLYMPIC BAR



A.2 UNIVERSAL GYM BENCH PRESS STATION



Appendix B

B.1 PHOTO CELL GATE

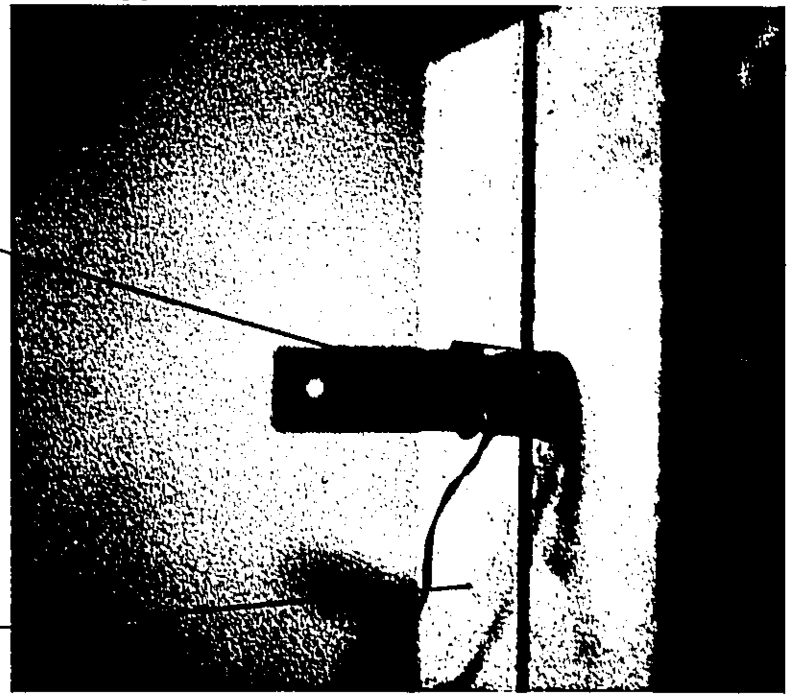
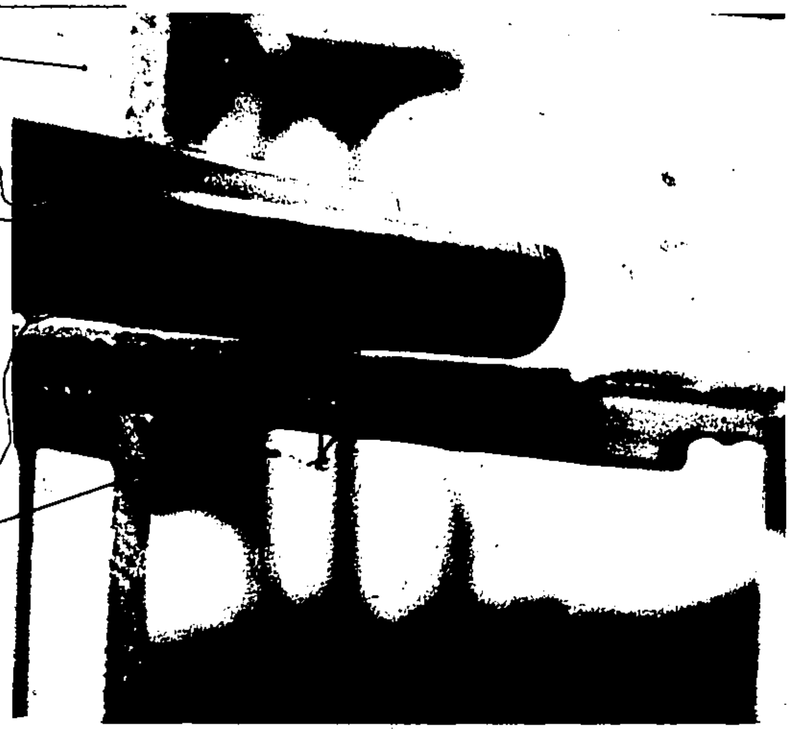


photo cell gate switch

support stand

B.2 MICRO PRESSURE SWITCH



support stand

load at pre-initiation point

micro pressure switch

Appendix C

FORMS

C.1. TEST FORM

Subject # _______ Age _______ (years)

Height _______ (inches) Weight _______ (pounds)

Years Of Weight Training Experience _______ (years)

Biacromial Width _______ X 1.5 = _______ (inches)

(test grip width)

Most Recent Single Repetition Bench Press Using An Olympic Bar (within the last month)

_______ X .6 = _______ (pounds)

(test load)

Trial #	Olympic Bar	Universal Gym
1		
2		
3		
4		
5		
6		
7		
8		

C.2 WAIVER FORM

I, ______________________________, authorize Philip Levesque to administer and conduct testing of my performance during two methods of bench pressing.

I understand that I will perform eight repetitions in total and that surface electrodes will be attached to my upper torso and limbs.

In agreeing to such a test, I waive any legal recourse against the members of the staff of the University of Ottawa or its agent for any and all claims resulting from personal injuries or death resulting from these tests. This waiver shall be binding upon my heirs and my personal representatives.

I have read the above, and understand it. Any questions which may have occurred to me have been answered to my satisfaction. I understand that I may ask additional questions at any time.

Signature ______________________________

Date ______________

Witness ______________________________

Appendix D

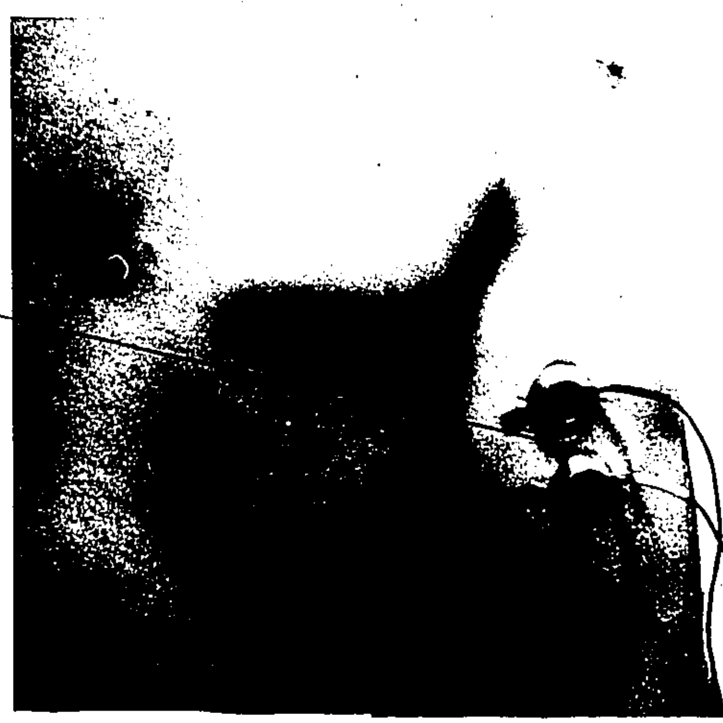
D.1 ELECTRODE PLACEMENTS

channel 2
anterior head of
deltoid electrodes

channel 1
pectoralis major
electrodes

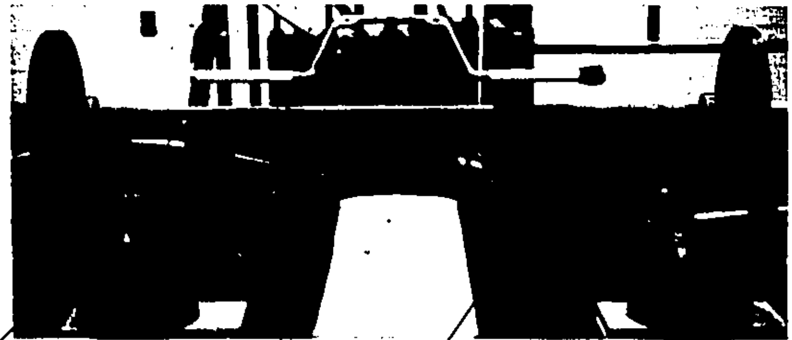
channel 4
biceps brachii
electrodes

channel 3
triceps
electrodes



Appendix E

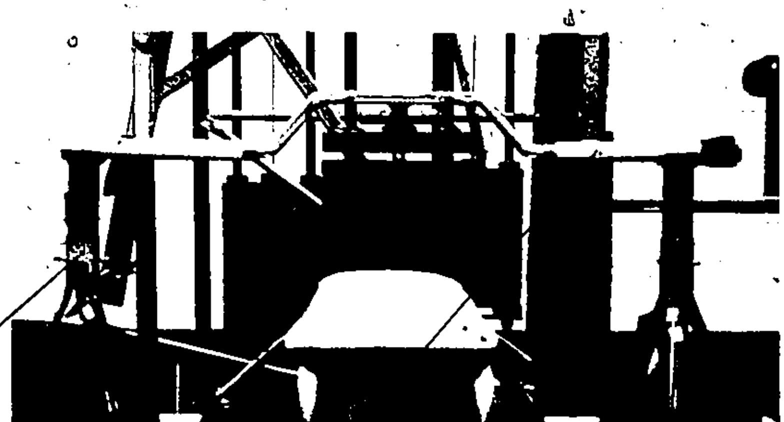
E.1 AXLE JACK SUPPORT OF OLYMPIC BAR



axle jack

test grip area

E.2 AXLE JACK SUPPORT OF UNIVERSAL GYM



axle jack

test grip area

Appendix F

Average Integrated Electromyographic Values Per Second

Subject	Channel 1		Channel 2		Channel 3		Channel 4	
	Olympic Bar	Universal Gym	Olympic Bar	Universal Gym	Olympic Bar	Universal Gym	Olympic Bar	Universal Gym
1	51000	415516	1465396	1455742	41292	359848	1446246	1441192
2	498887	440399	1566211	1480207	330427	445645	1438442	1447073
3	269513	289608	1458393	1467769	396076	650787	1447025	1452052
4	297576	288540	1517039	1518539	651985	656749	1456047	1452271
5	375674	281901	1597545	1560141	255675	178512	1456365	1454577
6	462789	413798	1501537	1473449	503283	541746	1451199	1449521
7	572218	244167	1774086	1701663	385071	429236	1441859	1453104
8	742707	791673	1589633	1510581	168658	164050	1445750	1451639
9	370013	253856	1463924	1441050	290173	330959	1461894	1462608
10	236578	252506	1456552	1481996	463520	316298	1458150	1459704
11	280727	225016	1459618	1457113	331753	299687	1452699	1453698
12	325966	408436	1458330	1455025	251093	377009	1456029	1456356
13	231805	222111	1481450	1457461	450800	329604	1461776	1470473
14	222158	290229	1457834	1473812	321141	329843	1457770	1460015