A QUANTITATIVE ELECTROMYOGRAPHIC STUDY OF THE TRAPEZIUS DURING SELECTED EXERCISES DESIGNED TO AMELIORATE THE POSTURAL DEVIATION DESIGNATED AS ROUND SHOULDERS

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CHAPTER I

ORIENTATION TO THE STUDY

Introduction

Be the name of the discipline Physical Education, Kinesiology or Movement Education, the instrument of expression is the human body, and one of the primary goals of the discipline is efficient functioning of that structure. The art and science of medicine first had this goal, and many of the early physical educators in the United States were physicians who used exercise as a form of therapy.[1]

The medically oriented physical educators believed that a primary purpose of physical education was "the care and development of the body."[2] Optimal health was believed to contribute to the goals of emotional and social effectiveness.[3] To implement these goals, many of the early physical educators administered periodic medical examinations and developed prescriptions for individual exercise to be performed by each student.

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[1] H. Harrison Clarke and David H. Clarke, Developmental and Adapted Physical Education (Englewood Cliffs, N. J.: Prentice-Hall, 1963), pp. 1-17.

[2] Ibid., p. 6.

[3] Ibid.

Posture improvement is a legacy from the early physicians who were physical educators.[1] Postural improvement, as a phase of the adapted physical education program, is often a neglected part of the modern physical education program. There are many justifications given for this neglect or omission--size of classes, insufficient professional preparation in the area of postural education, and lack of agreement concerning the criteria for evaluation of good posture by authorities.

Persons interested in adapted physical activities teach many different exercises which purport to ameliorate various postural deviations. Many, if not all, authorities in the area of adapted physical education differ with respect to their recommendations of specific exercises for use in the amelioration of such postural defects as round shoulders.[3] The exercises utilized by individual teachers are frequently selected upon an empirical rather than on a scientific basis. Electromyography offers a relatively new and unique means of evaluating exercises that are recommended to alleviate a postural defect.[4]

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[1]Arthur S. Daniels and Evelyn A. Davies, Adapted Physical Education (2nd ed. New York: Harper and Row, 1965), pp. 36-39.

[2]Clarke and Clarke, op. cit., pp. 8-23.

[3]Appendix I, p. 121.

[4]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louise: C. V. Mosby Co., 1968), p. 94.

The electromyographic technique of recording electrical activity of muscles during motor performance enables one to ascertain which exercises evoke the greatest amount of muscle action potential.[1] Hypotheses as to which are the most effective exercises for strengthening a particular muscle may be tested by this method.

Previous electromyographic studies of postures have been conducted primarily by physicians, who have substantiated many of the generally accepted concepts in posture education.[2,3] Electromyographic investigations pertaining to posture have generally considered certain specified movements; however, research upon the effectiveness of recommended postural exercises for the upper extremity is lacking. Basmajian in discussing postures specifically notes that "posture in the upper limbs, both while hanging freely downwards and in various other positions, too often gets ignored.[4]

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[1]J. V. Basmajian, Muscles Alive Their Functions Revealed by Electromyography (2nd ed. Baltimore: The Williams and Wilkins Co., 1967), pp. 137-143.

[2]Ibid., pp. 145-160.

[3]J. Joseph, Man's Posture Electromyographic Studies (Springfield, Illinois: Charles C. Thomas, 1960).

[4]Basmajian, op. cit., p. 146.

It is anticipated that the present investigation may provide insight into the relative effectiveness of selected exercises in the amelioration of the postural deviation of round shoulders. The specific condition of round shoulders was selected for investigation for several reasons among which were a concern for the evidenced weakness of arm and shoulder girdle strength in females in this country, a general consensus of authoritative opinion stating that strengthening of the trapezius and rhomboid is needed to correct round shoulders, and the frequency of round shoulders as evidenced by subjective observation and random application of Charles Lowman's criterion for determining round shoulders.[1]

Another reason for the selection of this topic is the realization that physical education needs to include activities and exercises that are designed to prevent the development of round shoulders by balancing the activity of the anterior muscles of the upper extremity with vigorous activities for the posterior muscles.[2] It is important to note that round shoulders and kyphosis are distinctly

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[1]Charles Leroy Lowman and Carl Haven Young, Postural Fitness (Philadelphia: Lea and Febiger, 1960), p. 108.

[2]Phillip J. Rasch and Roger K. Burke, Kinesiology and Applied Anatomy (3rd ed. Philadelphia: Lea and Febiger, 1967), pp. 365-366.

different conditions although they often occur together.[1] From the literature it appears that round shoulders is found more often without kyphosis than the reverse condition. It may be assumed, therefore, that if round shoulders are not corrected functional kyphosis may develop.

Statement of the Problem

The present investigation entailed a comparative study of twelve selected exercises recommended by authorities for the amelioration of the postural deviation known as round shoulders. Through a quantitative electromyographic study, the investigator attempted to ascertain the most efficient exercises for strengthening the trapezius and, by implication, therefore, for facilitating the possible correction of round shoulders. Twenty-one volunteer subjects who gave evidence of round shoulders from elementary schools, high schools, and universities in Denton, Texas, participated in the investigation.

Rationale of the Study

Eleanor Metheny in discussing "Exercise Forms"[2] provides the rationale for this investigation when she states that, "an exercise that is badly chosen may have no

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[1] *Ibid*., p. 368.

[2] Eleanor Metheny, *Movement and Meaning* (New York: McGraw-Hill, 1968), pp. 83-91.

lasting effect on the being of the performer or may damage his functional capacity rather than improve it."[1] The present investigation was undertaken in order to ascertain those exercises which best meet the criteria of strengthening the shoulder adductors and of being most appropriate to the ability of the subject with round shoulders of a particular age level.

The present study focused attention upon a neglected area of the body in that it attempted to evaluate selected exercises that are recommended for the amelioration of the postural deviation of round shoulders. The subjects selected for the investigation met the criterion of having round shoulders in order that data as realistic as possible could be obtained. Three age groups were studied so that the values of the exercises for various age groups could be considered.

Purposes of the Study

The general purpose of the present study was to rank the selected exercises in order of their probable value for alleviating the postural defect of round shoulders. Specifically, the following hypotheses were tested:

1. There is no significant difference in the muscle action potential of selected postural exercises which purport to strengthen the trapezius muscle, as measured by quantitative electromyography.

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[1] Ibid., p. 86.

2. There is no significant difference among subjects of various age levels in the muscle action potential of the selected postural exercises, as measured by quantitative electromyography.

Delimitations of the Study

This study was subject to the following delimitations:

1. Twenty-one female volunteer subjects representative of three different age groups were utilized in the present study.

2. Twelve exercises which entail adduction movements of the scapula due to contraction of the trapezius were ranked in the present study. Only exercises with common movements which were cited by three or more authors who had published books pertaining to adapted physical education since 1960 were included in the present study.

3. Only the trapezius was studied in the present investigation. Rasch and Burke[1] suggest that all four parts of this superficial muscle should be studied separately. Part III of the trapezius is the prime mover for adduction of the scapula; strengthening of the trapezius, while simultaneously stretching the pectorals, is an accepted procedure for ameliorating round shoulders. The third part of the

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[1]Rasch and Burke, op. cit., pp. 171-173.

trapezius, "includes the fibers that arise from the seventh cervical and the upper three thoracic vertebrae; these converge somewhat to the insertion on the spine of the scapula."[1]

4. Only surface electrodes were utilized for the collection of all data in the present study.

5. The body is a volume conductor and surface electrodes are not selective. The activity of the rhomboid muscle action was recorded to some degree by the electrodes placed upon the surface of the trapezius. For the same reason, the synergistic efforts of all parts of the trapezius were recorded.[2]

6. The ability of the investigator to operate properly the electromyograph and to analyze the data obtained from the electromyograph and accessory equipment was an obvious limitation.

7. Round shoulders were determined by the criterion of Lowman and Young.[3] A separation between the vertebral borders of the scapulae of five inches or more is considered

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[1] Ibid.

[2] John F. Davis, Manual of Surface Electromyography (Aerospace Medical Laboratory, Wright Air Development Center, Air Research and Development Command. Wright-Patterson Air Force Base, Ohio: United States Air Forces, 1959), pp. 24-25.

[3] Lowman and Young, op. cit., p. 108.

a severe deviation and was the minimum separation accepted for this investigation.

Definitions and/or Explanations of Terms

The definitions and/or explanations which follow are offered to clarify the basic terminology which was employed throughout the present study.

1. Electromyograph: For this study, the definition of J. V. Basmajian was accepted. This definition states that,

> . . . an electromyograph is a high gain amplifier with a preference or selectivity for frequencies in the range from about ten to several thousand cycles per second (cps). (Recently it has become conventional to use Hz--for Hertz--to denote cycles per second.)[1]

Quantitative electromyography, the technique utilized in the present study, entails the study of the amount of electrical activity which is present in a given muscle per time unit. The technique electronically integrates the electrical potentials, with the analogue recordings being converted instantaneously to a digital readout.[2]

2. Electromyography: The recording of muscle action potential is called electromyography.[3] Basmajian states

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[1] Basmajian, op. cit., p. 37.

[2] Herbert A. deVries, Physiology of Exercise (Dubuque, Iowa: William C. Brown Company, Publishers, 1966).

[3] Ibid., p. 22.

that, "electromyography is unique in revealing what a muscle actually does at any moment during various movements and posture."[1]

3. Electrodes: Electrodes pick up the action potentials every time a muscle contracts.[2] The electrodes which were utilized in this study were designed to be attached to the surface of the skin. Two of the electrodes, or small metal discs, were placed above the muscle being studied; the third electrode was placed at a distance from the other two to serve as a ground or reference electrode.

4. Muscle Action Potential: The investigator accepted deVries' description of muscle action potential as the electrical change which accompanies the contraction of muscle tissue. This change can be recorded and measured by electromyography.[3]

5. Posture: Rasch and Burke state that:

> . . . a posture is a position or a stance. There are, obviously, an infinite number of postures, and many of them are important in sports and work in physical education and in therapy.[4]

In this study, the term posture conformed to Rathbone and Hunt's description; that of a

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[1]Basmajian, op. cit., p. 22.

[2]Rasch and Burke, op. cit., p. 95.

[3]deVries, op. cit., p. 22.

[4]Rasch and Burke, op. cit., p. 69.

> . . . good active standing position, as viewed from the side in an extended standing position, the long axes of the main body segments form a vertical instead of a zigazg line, and the various body masses are in perfect alignment.[1]

6. Round Shoulders: To clarify this term, the investigator selected Mueller and Christaldi's explanation that,

> . . . the deviation known as round shoulders occurs when the scapulae assume an abudcted position due to the weakened condition of the trapezius and rhomboid muscles . . . the deviation, itself, is not related to the dorsal region of the spine, although portions of the spine frequently are affected by this condition.[2]

Summary

Electromyography offers an objective means of evaluating various movements to ascertain the preferred exercise to accomplish a specific purpose. It may be utilized by kinesiologists and physical educators to evaluate various activites which have previously been recommended as a result of personal experience and subjective judgement. By utilization of this scientific method a better understanding of the dynamic movements of the human body can be obtained.

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[1]Josephine L. Rathbone and Valerie V. Hunt, Corrective Physical Education (7th ed. Philadelphia: W. B. Saunders Co., 1965), p. 84.

[2]Grover W. Mueller and Josephine Christaldi, Remedial Physical Education (Philadelphia: Lea and Febiger, 1966), p. 67.

Posture as an area of general concern, has been studied by physicians and physical educators; however, various postures have normally been studied rather than the exercises to improve postural deviations. Teachers are, at present, confronted with numerous sources which describe many different exercises to ameliorate each specific postural deviation.

This study has attempted, by electromyography, to objectively evaluate recommended exercises for the amelioration of the postural deviation of round shoulders. Twelve exercises for the strengthening of the scapulae adductors were administered to twenty-one students of three different education levels. The selected exercises were ranked in order of their probable value for the alleviation of the postural defect of round shoulders; the ranking was based upon the data obtained from the subjects while they were performing the exercises with surface electrodes transmitting their muscle action potential to the electromyographic instruments.

This particular deviation was selected for several reasons as one appropriate for further study. Among the reasons were the frequency with which the condition is observed and the tendency to develop an imbalance between the anterior and posterior shoulder muscles because most work and activities stress action in front of the body.

A survey of previous studies related to this dissertation will be presented in Chapter II.

CHAPTER II

SURVEY OF RELATED LITERATURE

Volumes have been compiled pertaining to the study of posture, muscles, and electromyography; however, no study identical with the present one has been discovered. An historical overview of the areas related to the present study is included in this chapter, followed by a more specific discussion of the area of electromyography as it relates to the present study of exercises to ameliorate the postural deviation of round shoulders.

Historical Overview

The use of remedial exercises can be traced back to the ancient Greeks. Hippocrates is known to have prescribed exercises for patients with chronic illness.[1] Bastholm, in discussing the Hipprocratic theory of muscles in retrospect, states that despite the mastery of the details of superficial muscles in classical Greek sculpture, the knowledge of muscle physiology was non-existent.[2] The physicians of

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[1] Benjamin Lee Gordon, Medicine Throughout Antiquity (Philadelphia: F. A. Davis Company, 1949), p. 514.

[2] Eyrind B. M. M. Bastholm, The History of Muscle Physiology (Copenhagen: Enjar Munksgaard, 1950), p. 32.

that period had little understanding of the part played by the muscles in the origin and mechanism of movement.

Aristotle, in his treatise Parts of Animals, Movements of Animals and Progression of Animals,[1] considered the mechanics of movement and the advantages of the addition of resistance to movement. Scientific findings have proven that Aristotle was remarkably accurate in his observations concerning motion.

Galen brought the Greek concepts of medicine to Rome. There he continued to study the structure of the body of dissecting animals, including the ape. In addition, he observed the gladiators he trained as they fought in the arena; he later studied their exposed muscles as he treated their injuries.[2] Galen attributed muscle contractions to "animal spirits" which passed "from the brain through the nerves to the muscles."[3]

The Dark Ages proved a static period for any advancement in the understanding of movement, but the Renaissance produced the genius, Leonardo da Vinci. da Vinci, perhaps best known for his masterpieces of art, was equally talented

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[1]Aristotle De Part. An. De Motu De Incessu De Gen. trans. William Ogle (Oxford: Clarendon Press, 1911).

[2]Gordon, op. cit., pp. 698-701.

[3]Charles Singer, A Short History of Medicine (Oxford: Clarendon Press, 1928), p. 58.

as a scientist and as an engineer. He dissected human cadavers in order to understand the composition of the body. da Vinci's interest is beautifully expressed by him in the statement "would that it might please our Creator that I were able to reveal the nature of man and his customs even as I describe his figure."[1] His notebooks contained excellent diagrams exhibiting the action of muscles; the drawings of the shoulder muscles are particularly clear.[2] The notes made by da Vinci evidence great insight into anatomy and physiology. Unfortunately for the advance of science the anatomical drawings and manuscripts of Leonardo da Vinci remained hidden until recent times.[3]

The humanists translated and studied the medical writings of the past. Andreas Vesalius, unaware of the manuscripts and sketches of da Vinci, attempted to portray muscles in action in the living, moving, human organism.[4] Singer[5] and Sigerist[6] indicate that few disciplines are

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[1]Leonardo da Vinci, The Notebooks of Leonardo da Vinci, Vol. I. trans. Edward MacCurdy (New York: Reynal and Hitchcock, 1939), p. 101.

[2]Charles Singer, A Short History of Anatomy from the Greeks to Harvey (New York: Dover Publications, Inc., 1957), pp. 89-90.

[3]Cooper and Glassow, op. cit., p. 15.

[4]Ibid., p. 15.

[5]Singer, op. cit., p. 11.

[6]Henry E. Sigerist, On the History of Medicine, ed. Felix Marti-Ibanez (New York: MD Publications, Inc., 1960), pp. 160-161.

founded more strongly on the work of one man than is anatomy on the studies made by Vesalius. Unlike most anatomist of the twentieth century, Vesalius was concerned with living anatomy. He believed that the study of parts of the human body should not be limited to morphological treatment, but should encompass investigations of the complex structure of the living man. This belief is evidenced in Fabrica, in which sections of the anatomy are depicted as part of the total body.[1] In Epitome, which was intended for the non-medical reader, Vesalius illustrates realistically both the trapezium and the rhomboid muscles in the "Muscle Tabula."[2]

Luigi Galvani's Commentary on the Effects of Electricity on Muscular Motions, which was first published in 1791 informed other scientists of an accidental discovery made in his laboratory.[3] When an assistant touched an excised muscle of a frog with a metal scalpel, a battery upon a table released a spark and the muscle contracted vigorously. Galvani investigated this phenomenon and concluded that a muscle could be stimulated by electricity.

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[1]Singer, op. cit., p. 16.

[2]Andreas Vesalius, Epitome (Basel, Switzerland: Johannes Operinus Press, 1543), pp. 110-113 cited in the translation by L. R. Lind, The Epitome of Andreas Vesalius (New York: The Maxmillan Company, 1949), p. 123.

[3]Luigi Galvani, Commentary on the Effects of Electricity and Muscular Motion, trans. Margaret Glover Foley (Norwalk, Connecticut: Burndy Library, 1953), pp. 45-47.

He also demonstrated that muscles "produce a detectable current or voltage when they contract from any cause."[1] The findings of Galvani formed the basis for Electrophysiology.[2]

Guillaume Benjamin Amand Duchenne utilized the principle of electrical stimulation of muscles to study the dynamics of muscular contraction of intact, living, skeletal muscles. Duchenne discovered the function of isolated muscles by his faradization of muscles in healthy human subjects. He realized that muscles seldom work in isolation; therefore, he supplemented the information obtained by faradization with observation.[3]

Authorities in the field of modern electrophysiology find that most of the experiments of Duchenne have been substantiated as more refined techniques have been developed.[4] Duchenne described both the trapezius and rhomboid muscles in his book, Physiology of Motion,[5] first published in 1867.

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[1]Basmajian, op. cit., p. 3.

[2]Fielding H. Garrison, An Introduction to the History of Medicine (4th ed. Philadelphia: W. B. Saunders Company, 1960), p. 327 citing from Luigi Galvani De Viribus Electricitatis in Motu Musculari (Moderna, 1792).

[3]Guillaume Benjamin Amand Duchenne, Physiology of Motion, trans. Emanuel B. Kaplan (Philadelphia: W. B. Saunders Company, 1959).

[4]Ibid., p. xiv from the "Translator's Introduction."

[5]Ibid., pp. 1-22.

The only observation not substantiated is the respiratory function of the trapezius.[1] Basmajian states that no other person has contributed so much to the understanding of muscular function as has Guillaume Duchenne.[2]

Carolo Matteucci, in 1838, used an improvised galvanometer to demonstrate that electricity is generated by contracting muscle.[3] Emile DuBois-Reymond independently confirmed the flow of current from an isolated, contracted, striated muscle.[4] DuBois-Reymond is said by Licht to have been the first person to use human electromyography, in experiment performed in 1851.[5] Action currents were registered from the contracting arm of a man; jars of liquid were used as electrodes. Heomnoltz, between 1850 and 1852, investiaged the velocity of the impulses along a nerve by using the pendulum-myograph, he invented.[6] The time course

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[1]Basmajian, op. cit., p. 162. [2]Ibid., p. 4.

[3]Carlo Matteucci, "Electro-Physiology: A Course of Lectures by Professor Carlo Matteucci, Senator," trans. by C. A. Alexander, Annual Report of the Board of Regents of the Smithsonian Institution, 1865 (Washington: Government Printing Office, 1872), pp. 319-332.

[4]Ibid., pp. 323-332.

[5]Sidney Licht, Electrodiagnosis and Electromyography (2nd ed. New Haven, Connecticut: Elizabeth Licht, Publisher, 1961), p. 16 citing from A. Lucas, Vade Mecum d'Electrodiagnostic (Paris, 1916).

[6]Garrison, op. cit., p. 533 citing from Hermann von Helmholtz, Arch. f. Anat., Physiol. U Wissensch. Med. (Berlin, 1850), pp. 71, 276; (1852), p. 199.

of the action current in contracting muscle was shown by Bernstein in 1871; he also explained the diphasic form of the action current obtained when two electrodes were placed upon a muscle a few centimeters apart.[1] In addition, Bernstein investigated the negative variation and velocity of the propagation of action current.[2]

Charles Beevor was another outstanding contributor to the understanding of the actions of muscles. Beevor, in The Croonian Lectures on Muscular Movement,[3] of 1903, describes the three methods known in his time of ascertaining the action of a muscle: (1) anatomical, (2) faradization, and (3) physiological. The "anatomical method" is the partial dissection of the muscle which leaves the origin and insertion intact; the muscle is then pulled, and the resulting movement is noted. In discussing this method, Beever notes that only one muscle acts, performing all possible actions; this is not a normal situation. It is, however, the only means available for studying deep muscles. The electrical method of faradizing the muscle used by Duchenne is described as the second method. Beevor prefers the method of

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[1] Ibid., p. 536 citing from Julius Bernstein, Arch. f. d. ges. Physiol. (Bonn., 1897), LXVII, p. 207.

[2] Joseph, op. cit., p. 20 citing from Julius Bernstein, Monats. Berl. Akad (Wissen, 1867).

[3] Charles Beevor, The Croonian Lectures on Muscular Movements, edited and reprinted by the Gurantors of Brain (London: Macmillian and Company, Limited, 1951 but 1903 original).

faradization when the muscle is superficial because the muscle is living and undisturbed; however, it is noted that the muscle still acts in isolation. Beevor believes that this technique indicates what a muscle may do, not necessarily what a muscle actually does. The third method, which is called the "physiological or natural method," is considered the best one, by Beevor. In this method, an individual is told to perform a definite movement, and it is then observed which muscles take part in the movement. Beevor cautions that the remainder of the limb must be fixed and only the desired movement done; inspection and palpatation are used to ascertain muscle action.[1]

The galvanometer, developed by Einthoven in 1902,[2] allowed electromyographical techniques to be utilized for studying the amplitude and duration of electrical impulses generated by muscles in action.[3] Through the use of the galvanometer, it became possible to determine if muscles believed to be contracting during a certain movement were actually activated. Some beliefs were substantiated and others were refuted.

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[1] Ibid., pp. 1-2.

[2] Garrison, op. cit., p. 687, citing from Willem Einthoven, K. Akad. v. Wetensch. te Amst. Proc. Sect. Sc., 1903-1904, ve, 107-115, 2pl.

[3] Cooper and Glassow, op. cit., p. 16.

The first physiological discussion of electromyography appeared between 1910 and 1912 in a paper by H. Piper of Germany.[1] The initial recognition of the technique by English speaking countries is found in a paper published in 1925 that is attributed to E. D. Adrian.[2] Adrian stated that it was possible to determine the amount of activity in human muscles at any stage of movement.

Independent investigations by Denny-Brown and Adrian and Bronk in 1929 recorded functional activity of a single motor unit.[3] The latter physicians in the same year invented the coaxial needle electrode which provided an improved method for studying and recording neuromomuscular action potentials.[4]

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[1]Rasch and Burke, op. cit., p. 13, citing from H. Piper, "Elektrophyiologie Menschlicher Muskeln (Berlin: Springer-Verlag, 1912).

[2]E. D. Adrian, "Interpretation of the Electromyogram," Lancet, Vol. 2 (June, 1925), pp. 1229-1233 and 1283-1286.

[3]Alberto A. Marinacci, Clinical Electromyography (Los Angeles: San Lucas Press, 1955), p. 1, citing from E. D. Adrian and D. W. Bronk, "The Discharge of Impulses in Motor Nerve Fibers," and Part II "The Frequency of Discharge in Reflex and Voluntary Contraction," Journal of Physiology, Vol. LXVII (1929), pp. 119-151.

[4]Ibid.

Proebster is usually credited with beginning the clinical use of electromyography.[1] Both Licht[2] and Marinacci[3] discuss the development of clinical electromyography while Basmajian[4] states that early electromyography was applied to humans more for diagnostic and clinical reasons than for basic kinesiological study. As the Second World War ended, improved electronic equipment was utilized by anatomists and kinesiologists as well as by orthopedic surgeons. Basmajian[5] cites the study by Inman, Saunders, and Abbot[6] in 1944 which concerns research related to the movements of the shoulder girdle as the first kinesiological study that gained wide acceptance.

Kinesiologists Rasch and Burke note that one name stands pre-eminent in the study of the physiologic aspects of striated muscular activity, Archibald V. Hill.[7] They

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[1]Licht, _op. cit._, p. 16, citing from R. Proebster, "Uber Muscelaktion sstrome am gesunden und Kranken Menschen," Z. Orthop. Chir., Vol. L (1928), p. 1.

[2]Licht, _op. cit._, pp. 17-19.

[3]Marinacci, _op. cit._, pp. 1-3.

[4]Basmajian, _op. cit._, pp. 5-6.

[5]_Ibid._

[6]Verne T. Inman, J. B. Saunders and Leroy C. Abbott, "Observations on the Function of the Shoulder Joint," _Journal Bone and Joint Surgery_ (American), Vol. XXVI, No. 1, (January, 1944), pp. 1-30.

[7]Rasch and Burke, _op. cit._, pp. 13-17.

cite his work Muscular Movement in Man[1] as unquestionably distinguishing him as the world's leading authority in this field.[2] Although the mentioned book is pertinent to many phases of kinesiology, another book by Hill, Living Machinery, contains more data pertinent to electromyography.[3] The latter book offers valuable historical information in addition to his experiments and observations.

Because they are interrelated, the knowledge of the operation of striated muscle forms the basis for postural study. Perhaps a few historical studies of particular pertinency to posture should be cited. Singer states that the modern concept of locomotion developed as a result of the studies made by Borelli.[4] The Weber brothers, Ernst Heinrich, Wilhelm Edward and Eduard Fredrick Wilhelm, are credited with the scientific basis for the mechanism of muscular action.[5] The brothers believed that the erect position of the body was maintained primarily by tension of

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[1]Archibald Vivian Hill, Muscular Movement in Man: The Factors Governing Speed and Recovery from Fatigue (New York: McGraw-Hill, 1927).

[2]Rasch and Burke, op. cit., pp. 13-17.

[3]Archibald Vivian Hill, Living Machinery (New York: Harcourt, Brace and Company, 1927).

[4]Singer, op. cit., p. 120.

[5]Rasch and Burke, op. cit., pp. 6-8, citing from Ernst Heinrich Weber, Wilhelm Edward Weber, and Eduard Fredrick Wilhelm Weber, Die Mechanik der Menschlichen Gerverkzeuge (1836).

the ligaments and required little or no muscular exertion. They investigated the reduction of individual muscle length during contraction and they studied the role of bones as levers. The Webers were first to explain that the center of gravity of the body shifted as a person moved.[1] Christian Wilhelm Braune and Otto Fischer[2] in 1889 reported an experimental method for determining the center of gravity. Their method was based upon dissecting frozen cadavers with a saw and then locating the points of intersection of the three planes of each segment, thereby finding the center of gravity. The resulting centers of gravity were plotted upon a drawing of one of the cadavers, and the illustration was compared with a picture of a soldier having similar body measurements; a remarkable similarity was observed. Braune and Fischer concluded therefore that the orginal position of the frozen cadavers could be considered as a normal one and referred to that position as "normalstellung." This designation was intended to indicate that this was the standard position in which the measurements were taken; unfortunately, the term came to be understood as the ideal

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[1]Ibid., citing from J. B. Haycraft, Animal Mechanics Textbook of Physiology, ed. E. A. Schafer, Vol. II (New York: The Macmillan Company, 1900), pp. 228-273.

[2]Ibid., citing from Wilhelm Braune and Otto Fischer, Uber den Schwerpunkt des Menschlichen Korpers mit Rucksicht auf die Austrustung des Deutschen Infanteristen (Abh. sachs. Ges. (Akad.) Wiss., 1889), Vol. XV, pp. 559-672.

body position, and generations of students were taught to imitate it.[1]

A book by Joseph[2] and another by Phelps, Kiphuth and Goff,[3] present excellent discussions of the evolutionary development of posture. Both sources include sections pertaining to the change of emphasis from imitation of an "ideal posture" to the designed concept of "form follows function."

The historical overview presented has shown the development of knowledge of the human body from the time of Hippocrates to the present. Developments in many sciences have influenced the improved understanding of the movements of man. In the following pages, materials directly related to this study are reviewed.

Numerous volumes and portions of books have been written about various postures. The eleven post 1960 publications from which the exercises for the present study were obtained are listed in Appendix I, page 121. Only one of the books, Adaptation of Muscular Activity by Gene Logan and James G. Dunkelberg showed any indication that electromyography might

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[1] *Ibid.* [2] Joseph, *op. cit.*, pp. 3-17.

[3] Winthrop Morgan Phelps, Robert J. H. Kiphuth and Charles Weer Goff, *The Diagnosis and Treatment of Postural Defects* (2nd ed., Springfield, Illinois: Charles C. Thomas, 1965), pp. 3-64.

[4] Gene A. Logan and James G. Dunkelberg, *Adaptation of Muscular Activity* (Belmont, California: Wadsworth Publishing Company, 1964).

have served as a guide in the development of exercises; however, no statement to this effect was made in the book. The importance of several factors was stressed for improved posture. The majority of the authors agreed that strenghening of the scapulae adductors was needed to ameliorate the postural condition of round shoulders. The recommendations in these books are based upon experience and subjective judgements. It is of historical interest that a similarity exists between many exercises recommended in books of this decade and exercises advocated by McKenzie in the first decade of this century; however, no device is as torturous in appearance as the apparatus for stretching round shoulders he pictured.[1] Other noteworthy information upon posture was obtained from books by Metheny;[2] Licht;[3] Davies;[4] Williams and Worthingham;[5] and Broer.[6]

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[1]R. Tait McKenzie, Exercise in Education and Medicine (Philadelphia: W. B. Saunders Company, 1910), p. 265.

[2]Eleanor Metheny, Body Dynamics (New York: McGraw-Hill Book Company, Incorporated, 1952).

[3]Sidney Licht, ed., Therapeutic Exercise (New Haven, Connecticut: Elizabeth Licht, Publisher, 1958).

[4]Evelyn A. Davies, The Elementary School Child and His Posture Patterns (New York: Appleton-Century-Crofts, Incorporated, 1958).

[5]Marian Williams and Catherine Worthingham, Therapeutic Exercise (Philadelphia: W. B. Saunders Company, 1957).

[6]Marion R. Broer, Efficiency of Human Movements (2nd ed., Philadelphia: W. B. Saunders Company, 1966).

Kinesiology texts usually contain some postural discussion; examples of books with references to postures not previously included in the study are the works of Steindler;[1] Scott;[2] Wells;[3] and Bowen and Stone.[4] Although authoritative scources of information in many ways, the understanding of muscles by the authors of these texts is based upon observation of dead muscles or palpitations. Brunnstrom[5] was the only author who included systematic references to electromyographic data to amplify the above methods.

Basic tests and measurements books for health and physical education such as Matthews,[6] and Larson and Yocum[7] include a section upon postural evaluation. Meyer and

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[1]Arthur Steindler, Mechanics of Normal and Pathological Locomotion in Man (Springfield, Illinois: Charles C. Thomas, 1935).

[2]M. Gladys Scott, Analysis of Human Motion (2nd ed., New York: Appleton-Century-Crofts, 1963).

[3]Katharine F. Wells, Kinesiology (4th ed., Philadelphia: W. B. Saunders Company, 1966).

[4]Wilbur Pardon Bowen and Henry A. Stone, Applied Anatomy and Kinesiology (7th ed., Philadelphia: Lea and Febiger, 1953).

[5]Signe Brunnstrom, Clinical Kinesiology (2nd ed., Philadelphia: F. A. Davis, 1966).

[6]Donald K. Matthews, Measurement in Physical Education (2nd ed., Philadelphia: W. B. Saunders Company, 1963).

[7]Leonard A. Larson and Rachael Dunaven Yocum, Measurement and Evaluation in Physical Health, and Recreation Education (St. Louis: C. V. Mosby Company, 1951).

Blesh[1] present an excellent discussion of existing tests for evaluating posture. Although many studies are cited in the publications mentioned above, a few other investigations of posture which are somewhat relevant to the present study should be mentioned. Amsdem[2] studied the postures of college women in relation to convexity of the dorsal spine, and Coppock[3] studied the tightness of pectoral muscles of college women. Studies concerning the postures of younger children were reported by Davies,[4] Moriarity,[5] and Flint and Diehl.[6] Kuhn[7] discussed the delayed effects of minor

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[1]Carlton R. Meyer and T. Erwin Blesh, Measurement in Physical Education (New York: The Ronald Press Company, 1962).

[2]Katherine Amsden, "A Postural Study of Smith College Women Exhibiting a Reduction in the Convexity of the Dorsal Spine" (unpublished M.S. thesis, Smith College, 1956).

[3]Doris Coppock, "Relationship of Tightness of Pectorial Muscles to Round Shoulders in College Women," Research Quarterly, XXIX (May, 1958), 146-153.

[4]Evelyn H. Davies, "Relationship Between Selected Postural Divergencies and Motor Ability," Research Quarterly, XXVIII (March, 1957), 1-4.

[5]Mary Moriarty, "A Study of the Relationship of Certain Physical and Emotional Factors to Habitual, Poor Posture Among School Children" (unpublished D.Ed. dissertation, Boston University, 1950).

[6]Marilyn Flint and Bobbie Diehl, "Influence of Abdominal Strength, Back Extensor Strength and Trunk Strength Balance Upon Antero-Posterior Alignment of Elementary School Girls," Research Quarterly, XXXII (December, 1961), 496-498.

[7]J. G. Kuhn, "The Late Effects of Minor Degrees of Poor Posture," Physical Therapy Review, Vol. XXXIX, No. 4 (April, 1949), pp. 165-168.

postural divergencies, while Kraus[1] presented an evaluation of posture based upon selected structural and functional measurement. Lane[2] studied the strength of certain muscle groups in relation to the posture of students majoring in health, physical education and recreation. Fox[3] considered the relationship of abdominal strength to postural faults.

Basmajian,[4] in the book Muscles Alive, included a section upon posture studies. Electromyographical research was the focus of this text and in it Basmajian noted that studies of the upper limbs were lacking.

Joseph[5] utilized electromyographical techniques to investigate postural mechanics with special reference to the back and lower limbs. Joseph conducted very few experiments with needle electrodes because the subjects complained of a dull ache in the region of the needle's insertion after several contractions of the muscle. Joseph concluded that

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[1]Hans Kraus and S. Eisemenger-Weber, "Evaluation of Posture Based on Structural and Functional Measurements," Physiotherapy Review, Vol. XXV, No. 6 (November-December, 1945), pp. 267-271.

[2]Barbara J. Lane, "A Study of Antero-Posterior Posture and the Strength of Certain Muscle Groups of Major Students in the College of Health, Physical Education, and Recreation at the Texas State College for Women (unpublished Master's thesis at Texas Woman's University, 1956).

[3]Margaret Fox, "Relation of Abdominal Strength to Postural Faults," Research Quarterly, XXII (May, 1951), 141-144.

[4]Basmajian, op. cit.

[5]Joseph, op. cit.

needle electrodes were an undesirable method of investigating normal postures and subsequently consistently employed surface electrodes for the remainder of the research investigations.

One of Joseph's principal findings was that all postural muscles are not active when the subject is standing at ease. Joseph suggested that muscle tone be defined as "the response of a muscle to being stretched under certain conditions, and that relaxed muscles show no detectable electric activity."[1]

Hirschberg and Dacso[2] discussed electromyography as a kinesiological tool for studying the upper extremity of normal and abnormal subjects during basic movements, such as drinking a glass of water and combing the hair. This study has an excellent evaluation of electromyographical techniques for kinesiological studies. A multi-channel electromyograph was used which allowed simultaneous recording of several muscles. The sequence and magnitude of muscle activity could be studied with the multi-channel recorder. The sequence and magnitude of muscle action

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[1] _Ibid_., p. 74.

[2] Gerald G. Hirschberg and Michael M. Dacso, "The Use of Electromyography in the Study of Clinical Kinesiology of the Upper Extremity," _American Journal of Physical Medicine_, XXXII (February, 1953), 13-21.

potential was reported and discussed for each of the muscles involved during the specific activities studied.

O'Connell and Gardner[1] undertook a study concerning the use of electromyography for kinesiological research. It was stated that a thorough kinesiological analysis should be performed in order to develop a research design for electromyography. A simultaneous pictorial record of the action upon the myogram was found to be of value in analyzing the movement. The action of all muscles, including the postural ones, must be considered in interpreting any kinesiological electromyograms.

Inman, Saunders, and Abbott[2] studied the four lesser joints that comprise the shoulder joint from several aspects: comparative anatomy, roentgenography for analysis of motion and theoretical force requirements, and the action current potential derived from the living muscle during motion. The data were synthesized for a better understanding of the complex functioning of the shoulder joint. The myograms caused the authors to conclude that prime movers, as ordinarily understood, do not exist; there are only patterns of movement.

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[1]A. L. O'Connell and E. B. Gardner, "The Use of Electromyography in Kinesiological Research," Research Quarterly, XXXIV (May, 1963), 166-184.

[2]Inman, Saunders, and Abbott, op. cit., pp. 1-30.

Yamshon and Bierman,[1] in one of a series of studies concerning the kinesiological use of electromyography, investigated the trapezius muscle. They noted that the movements that are ordinarily attributed to the trapezius can be performed, though incompletely and weakly, even when the muscle is paralyzed by surgically sectioning the affiliated spinal nerve. The objective of the study by Yamshon and Bierman was to observe the relationship of the action of the trapezius to that of other muscles in the scapulae adductor group.

Yamshon and Bierman found needle electrodes unsatisfactory and consequently used surface electrodes for most of their observations. The muscle was studied by recording electromyograms from the upper, middle, and lower portions of the trapezius. The middle portion was studied during specific movements while the subject was in a vertical position, in a prone position, and also while the subject was lying upon the right side; all movements were studied upon the left trapezius muscle. The conclusion concerning the middle portion of the trapezius was that it performs elevation and adduction; it also aids in scapulae rotation. Body position did influence the magnitude of action potentials.

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[1]Leonard J. Yamshon and William Bierman, "Kinesiologic Electromyography: Part II, the Trapezius," Archives of Physical Medicine, XXIX (October, 1948), 647-651.

Wiedenbauer and Mortensen[1] utilized surface electromyography to analyze the action of the trapezius muscle during a series of voluntary movements performed by eleven normal adult male persons upon two different occasions. Seven pairs of electrodes were attached to the right trapezius before the movements were executed from a sitting position. The operator signaled "begin" and the subject said "stop" at the end of the movement. The movements were performed at an average, uniform speed without any special effort.

Photographic recordings for the muscle action potential of the movement of each individual were divided into eight phases, and the amplitude of the potentials for each of the phases was measured in millimeters. The measurements were plotted upon a graph for each individual, and a mean amplitude was determined for the group. Total amplitudes for each lead were determined also and plotted for each person. These amplitudes were plotted for all individuals upon a single chart, in order to study the variations between the subjects.

During retraction of the shoulders, the middle and lower portions of the muscle were most active. The activity

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[1]M. M. Wiedenbauer and O. A. Mortensen, "An Electromyographic Study of the Trapezius Muscle," American Journal of Physical Medicine, XXXI (February, 1952), 363-372.

varied considerably between subjects, but generally there was a greater increase of muscle action potentials for the lower fibers than for the middle fibers. During the movement of retraction, a gradual increase in muscle action potential occurred during the initial half of the movement, then rose suddenly to a maximum, and started a slow decline before the end of the movement. The study was qualitative; therefore, variations in patterns were considered more important than variations in amplitude. The greatest activity of the whole trapezius muscle was ascertained during the early abduction of the arm to 180 degrees, and slightly less activity occurred during retraction of the shoulder.

Bearn[1] used surface electromyography to study the upper trapezius in addition to four other muscles during static loading of the arms. The recordings were obtained for an initial five minute period during which the subject assumed a relaxed standing position followed by a five minute period during which the subject held an empty canister The canisters, which were held until fatigue occurred, were symmetrically loaded with lead weights up to ten and later twenty-five pounds. With respect to the upper trapezius, little or no activity was noted when no weight was held in

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[1] J. G. Bearn, "An Electromyographic Study of the Trapezius, Deltoid, Pectoralis Major, Biceps and Triceps Muscles During Static Loading of the Upper Limb," Anatomical Record, CXL (June, 1961), 103-107.

the canister. With weights in the canister most subjects could hold the position with little or no activity. Bearn cautions that failure to utilize the muscles supporting the shoulder joint and the shoulder girdle in bearing weight of the body on the hands may be a factor in injuries of the costo-clavicular space.

Flint and Gudgell,[1] by electromyography, studied the rectus abdominis and the external oblique muscles during seventeen exercises which are used commonly to develop abdominal strength. The authors state that "a discriminating selection of the most effective movements can be accurately determined by comparing the data on the recorded electromyographs."[2] Ten college women served as subjects for the series of exercises in which surface electrodes were used exclusively. The researchers reported that graphs of activities for different individuals depicted a similar pattern of muscle activity. The differences were found to be in the intensity of potential activity rather than in the pattern. Of the seventeen exercises studied, the authors listed five exercises as most effective, seven exercises as mildly to moderately effective, and the

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[1]Marilyn M. Flint and Janet Gudgell, "Electromyographic Study of Abdominal Muscular Activity During Exercise," Research Quarterly, XXXVI (March, 1965), 29-37.

[2]*Ibid*., p. 29.

remainder at least effective as revealed by the magnitude of action potential.[1]

Lipetz and Gutin[2] compared the effects of four abdominal exercises upon the muscle action potential of the upper and lower rectus abdominis of seven male high school gymnasts and one freshman college wrestler. Two surface electrodes were attached to the uppermost segment of the rectus muscle during one series of exercises and over the lowest segment of the same muscle for another series of the same exercises.

Ten repetitions of each of the four exercises weres performed; a rest period was given before the electrodes were relocated upon the muscle. A six count cadence was maintained for each exercise. The electromyographic instrument which was utilized for the study provided integrated data which were recorded upon myograph paper that was marked off by a series of squares. All quantitative values were derived from the squares as a basic unit of measurement.

The three types of sit-ups provided significantly greater intensity of action potentials than the leg lift,

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[1] Ibid., pp. 31-36.

[2] Stanley Lipetz and Bernard Gutin, "An Electromyographic Study of Four Abdominal Exercises" (paper presented at the meeting of the American Association for Health, Physical Education and Recreation Research Section, Saint Louis, Missouri, April 1, 1968. Ditto.).

but none of the sit-ups was significantly different from the others at the .05 level of confidence.

The intensity and duration of the electromyographic recordings were higher in the upper rectus abdominis than in the lower rectus abdominis for every subject in each activity. The arched back sit-up resulted in a significantly greater duration of muscle action potentials than did the others. Lipetz and Gutin suggested that the strenuousness of the arched back sit-up makes it advisable for skilled individuals only. The subjects who are not skilled should use another type of sit-up for strengthening of the rectus abdominis muscle.

Broer and Houtz[1] attempted to determine through surface electromyographical techniques if there were patterns of muscular function common to various sports skills. Thirteen different sports skills were studied involving sixty-eight different muscles on one skilled female physical education instructor during a two week period. It was possible only to determine the commonness of movement patterns for that one subject; however, electromyograms were recorded for other simple movements in order to compare the recordings upon this single subject with the findings of previous studies

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[1]Marion R. Broer and Sara Jane Houtz, Patterns of Muscular Activity in Selected Sport Skills: An Electromyographic Study (Springfield, Illinois: Charles C. Thomas, 1967).

and thereby to reduce the limiting effect of a single subject. Paired surface electrodes were applied to both the right and left portions of the upper, middle, and lower trapezius during each movement; however, different combinations of muscles were later recorded simultaneously to assist in coordinating trunk and upper extremity records. Each activity was performed three or more times for each set of muscles. The electromyographic movement patterns were found to be very similar, and therefore typical records were chosen for analysis.

The movement patterns considered by Broer and Houtz are the underarm, overarm, and sidearm patterns. A comparison of three throwing movements is included also. The final comparison is between the one-foot jump recorded from the subject during a volleyball spike and again during a basketball lay-up movement.

It was noted that single arm activities are non-existent since the non-dominant arm and the shoulder girdle are important for stabilization, balance, and reinforcement during all arm activities. Because this was a qualitative electromyographic study, the data were presented only by illustrations of the typical electromyograms and parallel pictures. These data were compared by the authors in a narrative manner.

Randall[1] studied two methods of chinning, utilizing electromyographic techniques. The biceps brachii, brachialis, brachioradialis, and the pronator teres were investigated. The efficiency of the pronated and supinated positions of the forearms during standard chinning procedures was compared. Randall concluded that the supinated position of the forearm was the more efficient method for chinning.

Pauly[2] used fine wire electrodes inserted into the deep muscles of the back and into the gluteus maximus to study twenty-six specific movements and exercises performed by twenty young men and women. The best exercises were selected upon the basis of the strength of the contractions produced as recorded on the electromyograph. The best exercises for strengthening the deep muscles of the back were those exercises which included hyperextension of the back from a prone position. Pauly stated that "the integrated electromyogram is an excellent tool for the evaluation of exercise."[3]

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[1]Nellie Genoa Randall, "An Electromyographic Study of Selected Muscles Involved in Two Methods of Chinning"(a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Division of Physical Education in the Graduate College of the State University of Iowa, August, 1963).

[2]John E. Pauly, "An Electromyographic Analysis of Certain Movements and Exercises," Anatomical Record, CLV (June, 1966), 223-234.

[3]*Ibid.*

Of the exercises studied which involved hyperextension of the trunk, the prone arch with arms extended was found to be the best of the three exercises. The other two included a prone arch with arms at the side and a prone arch with arms at the side while the legs executed a flutter kick.

Hogue[1] studied the muscular activity of the upper extremity during walking at different speeds by electromyography. A physiograph and a telemetry system were utilized to obtain electromyographic recordings of sixty muscles from fifteen college students; intramuscular copper wire electrodes were used to pick up the electrical activity. Hogue concluded that the arms did not act as pendulums during walking, but that both gravity and momentum are factors that are responsible for the arm swing. Hogue further concluded that the scapular and humeral muscles work with the contralateral leg muscles during the gait cycle.

Sigerseth[2] conducted an electromyographic study of selected muscles involved in movements at the scapulohumeral,

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[1] Raymond E. Hogue, "An Electromyographic Study of Upper Extremity Muscular Activity at Different Cadences and Grades During Normal Gait," Abstracts of Research Papers, 1968 (Washington, D.C.: American Association for Health, Physical Education and Recreation, 1968), 28.

[2] Peter Olaf Sigerseth, "Electromyographic Study of Selected Muscles Involved in Movements at Scapulohumeral, Acromioclavicular, Sternoclavicular Joints" (a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Division of Physical Education in the Graduate College of the State University of Iowa, June, 1958).

acromiclavicular, and sternoclavicular joints. The trapezius was one of the muscles studied. Five male graduate students participated in the experiment. Movement on a shoulder wheel, or with a dumbbell, were performed by each subject with surface electrodes attached to the designated muscle. Values were assigned to the electromyographic recordings based upon the height of the action potential peak. Sigerseth reported the findings for each movement both graphically and in narrative form. He concluded that different individuals utilized the same muscles studied in a similar manner, but that the intensity of muscle action varied between subjects as they executed idential exercises.

Close, Nickel, and Todd[1] studied the significance of motor-unit action-potential counts obtained from isometric and isotonic contractions. The quantitative electromyographic technique was utilized to measure the tension in voluntarily contracting soleus muscles of six normal human subjects with two internal electrodes. Preliminary research established that the behavior of the one inch area of the muscle between the two active internal electrodes could be considered characteristic of the entire muscle. The authors noted that surface electrodes yielded a lower action

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[1]J. R. Close, E. D. Nickel, and F. N. Todd, "Motor-Unit Action-Potential Counts: Their Significance in Isometric and Isotonic Contractions," Journal of Bone and Joint Surgery (American), XLII (October, 1960), 1207-1222.

potential than internal dual electrodes which were used. Close, et al, concluded that both isometric and isotonic contractions can be studied by electromyography using an electronic counter provided that conditions are carefully controlled.

Inman, et al,[1] studied the relation of human electromyograms to tension within the muscles of the lower limbs of amputees. A positive correlation was found between tension and the recorded electromyograms in a muscle of a fixed length. The type of electrodes used was found not to make a significant difference in the findings.

Flint[2] compared by surface electromyography the functions of the rectus abdominis and the external oblique muscles during the performance of ten variations of sit-ups by ten university women. The patterns of muscular action were similar in all of the sit-up variations; the initial and final stages of the exercises showed strong action of the abdominal muscles. The trunk raising phase recorded more electrical activity than the trunk lowering phase. The most effective exercises for the abdominal muscles were as

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[1]Verne T. Inman, et al, "Relation of Human Electromyography to Muscle Tension," Electroencephalog and Clinical Neurophysiology, IV (May, 1952), 187-194.

[2]M. Marilyn Flint, "Abdominal Muscle Involvement During the Performance of Various Forms of Sit-Up Exercise," American Journal of Physical Medicine, Vol. XLIV, No. 5 (October, 1965), pp. 224-234.

follows: trunk curl, knees flexed to a forty-five degree angle, with a trunk twist performed either with or without the feet being supported; trunk curl, knees flexed to forty-five degrees, feet supported; and sit-up, knees flexed to forty-five degrees, feet supported.

Slaughter,[1] for her doctoral dissertation, studied the muscles of the upper right arm by surface electromyographic techniques. Ten exercises were performed by the four male subjects. Each of three subjects was tested until two similar recordings were obtained for each of his movements. The fourth subject provided only one series of electromyograms. A rating of the magnitude of muscle spikes was utilized for analytic purposes as follows: none was zero; weak was one; moderate was two; and strong was three. The changing of the magnitude was noted by "i" for increase, "d" for decrease, and "s" for same. The findings were presented in four tables. Slaughter concluded from the findings that both heads of the biceps brachii aid in movements that require humeral extension and forearm flexion; however, the action was greatest when the forearm was supinated. Both heads of the muscle also aided in forearm flexion and pronation; however, the action potentials were greater for forearm

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[1]Diane R. Slaughter, "Electromyographic Studies of Arm Movements," Research Quarterly, XXX (October, 1959), 326-337.

flexion with supination than for forearm flexion with pronation. There was little or no action potential in the biceps brachii for movements with supination in which forearm extension was hindered. There was little or no action potential for the long head of the triceps during any of the specified movements. The pronator teres aided in forearm flexion and pronation and in forearm flexion and supination; the action potential was greater when the arm was supinated than when it was pronated.

O'Connell and Mortensen[1] studied the tibialis anterior muscle in order to observe the inner details of the relative activity.in different portions of the muscle during graded voluntary movements of normal subjects. Eight pairs of surface electrodes, as well as intramuscular electrodes, were used to collect the data from several parts of the muscle. The myograms showed the recruitment of additional motor units and the increase in frequency of the same motor unit during increased effort. The distribution of action potential, presumably from the same motor unit, was thought to evidence the spatial distribution of the motor units. The upper portion of the tibialis anterior consistently displayed a higher frequency and a lower threshold of activity than the

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[1]Alice L. O'Connell and O. A. Mortensen, "Interpretation of the Electromyogram of Graded Voluntary Movements in Normal Subjects," Anatomical Record, XXIV (February, 1956), 465.

lower portion; these differences were most apparent during minimal effort, but they remained detectable during moderate contractions.

In 1965 deVries[1] studied muscle tone in five postural muscles to discover the source of very low level electrical activity recorded from surface electrodes and to test the hypothesis of electrical silence in postural muscles. Thirty-three college men served as the subjects for the electromyographic study. Recordings were made under conditions of easy standing and in a position of rest. deVries discussed the very exacting requirements for electromyographic equipment as part of this article; the equipment described is the same general type which was used for the present study. deVries concluded that muscular silence did exist in well-relaxed postural muscles. deVries found that, in the position of easy standing, the gastro-soleus and anterior tibialis were constantly active and that the erector spinae and hamstring muscle groups were significantly more active in the easy standing position than in the resting position.

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[1]Herbert A. deVries, "Muscle Tonus in Postural Muscles," American Journal of Physical Medicine, XLIV (December, 1965), pp. 275-291.

deVries,[1] in 1968, using quantitative electromyographic techniques, explored two hypotheses: whether neuromuscular tension is reduced after exercise and whether exercise has a long-term effect upon the neuromuscular system. Twenty-nine male and female physical education students volunteered as subjects. Each subject was tested twice, one time immediately before and after exercise which consisted of a five minute step test, and the other time immediately before and after a five minute rest which served as the control situation. The lowering of neuromuscular tension after the exercise was significant at the .05 level in the right elbow flexor muscle group; it was not significant in the right quadriceps femoris muscle group.

The second experiment concerning long-term effects of exercise was performed with the same equipment upon eighteen male members of the university faculty with a mean age of 40.4 years. The subjects were tested and a subgroup formed for comparative purposes. This control subgroup maintained their former moderate activity. The members of the experimental group received instruction in heavy resistance exercises and the use of interval training for developing the ability to run a mile without resting. The experimental

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[1]Herbert A. deVries, "Immediate and Long Term Effects of Exercise upon Resting Muscle Action Potential Level," The Journal of Sports Medicine and Physical Fitness, Vol. VIII, No. 1 (March, 1968), pp. 1-11.

group was retested after seventeen workouts, each of one hour's duration. The control group was retested also upon the same three muscle groups after approximately the same length of time had elapsed between tests. Only the change of muscle action potential in the right elbow flexor muscle group in the experimental group was significant at the .05 level. The conclusion was that physical exercises may provide significant relief from hyperactive neuromuscular states.

Summary

In this chapter was included a survey of selected literature related to the present study. An historical overview of the areas related to the understanding of posture and the human body as well as electromyography was presented. The ancient Greek concepts were noted and changes in these concepts through the Roman period and the Dark Ages illustrated. The Renaissance provided much new knowledge of movement and the function of the human body.

Electrophysiology was traced through the contributions of Galvani, Duchenne, Beevor, DuBois-Reymond, Piper, Adrian, Hill and others such as the Webers, and Fisher and Braune, to the middle of the twentieth century.

As the Second World War ended, some anatomists, kinesiologists, and medical clinicians used improved electronic equipment to explore the dynamic action of striated muscle in the human body. The dissemination of the information obtained from electromyographic observations has been lacking, as is evidenced by the survey of books relating to adapted physical education, posture, anatomy, kinesiology, and physiology. Muscles Alive by Basmajian[1] was written to provide electromyographic knowledge for other fields. Joseph,[2] in Man's Posture, presents the development of knowledge of posture from other research techniques as well as from electromyographic studies.

The remaining research studies were selected as a result of their pertinence to a particular phase of the present study. Certain of the studies were concerned with the total posture of the individual, others with the general mechanics of selected areas of the body. A number of studies presented were of value because they pertained to the investigation of exercise by electromyography or because their discussion of the use of equipment or handling of data might be relevant to the present study.

In the following chapter, procedures utilized in the completion of the present study are described.

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[1]Basmajian, op. cit.

[2]Joseph, op. cit.

CHAPTER III

INSTRUMENTATION

Electromyography is the recording and study of the electrical changes in contracting muscle. These changes result in a pattern of potentials detectable by sensitive electronic equipment. The equipment needed for electromyography may be obtained either in an all inclusive console model, or the various components may be purchased in separate housing so that the completed unit can be tailored to meet the requirements of the research. Several separate components comprise the electromyographic equipment utilized for the present study.

Monitor Function Requirements and Description

The monitor receives the potentials of the muscle action detected by the electrodes as input. These electrical variations are amplified by the monitor and them applied to one or more appropriate display mediums.[1] Considerable amplification is required for recording electromyograms, since the voltage available at the electrodes developed by

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[1]Licht, Electrodiagnosis and Electromyography, p. 45.

"voluntary muscle are of the order of tens or hundreds of microvolts."[1] These minute voltages are increased by amplification--usually about a million times before they are at a sufficient power level for display.[2]

The monitor utilized for the present study was a Newport Laboratories Integrating Bioelectric Monitor, Model 100.[3] It is a voltage measuring instrument with a switchable gain and bandwidth which make it adaptable to all AC bioelectric phenomena. The monitor is the primary component utilized for electromyography. One of the most important innovations found in the integrating bioelectric monitor "is its ability to integrate data over precise time intervals--by means of voltage-to-frequency conversion, with pulse counting in an accessory counter."[4] The integration method produces much more accurate amplitude information than any kind of instantaneous measurement of broadband or filtered data. Further, the technique of integration by frequency-counting provides the convenience of an automatic result in digital form.[5]

The muscle action potentials were integrated or summated by the monitor over a set period of time. The muscle

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[1] _Ibid._ [2] Davis, _op. cit._, p. 47.

[3] _Integrating Bioelectric Monitor Model 100_ (Newport Beach, California: Newport Laboratories, Inc., 1968), p. 1.

[4] _Ibid._ [5] _Ibid._

action potential input to the monitor were displayed visually upon the accessory Hewlett-Packard Oscilloscope Model 120B. The integrated potentials of muscle action were quantitatively displayed by the Hewlett-Packard Electronic Counter Model H22 5211B, modified. The Electronic Counter produced a digital display of an integral phenomenon over a ten second period. The Newport Bioelectric Monitor includes a built in visual display operating from a sweep hand on a dial in units of ten to one hundred. The electrical potentials may be detected auditorially from a loudspeaker output which is part of the monitor. The monitor integrated the voltage input that came from the electrodes that acted as transducers or changers of the initial phenomenon and converted it simultaneously to pulses appropriate to digital display. The numerals displayed on the electronic counter were the data utilized in the present study. The counter provided an accurate reading of average, absolute voltage over a ten second period.[1]

Although the oscilloscope did not serve as important a function in the present study as it would in qualitative electromyography, it still was a vital item of equipment. It was essential to the pretesting of the electromyographic

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[1] Operating and Service Manual Model 5211B Electronic Counter (Palo Alto, California: Hewlett-Packard Company, 1965), p. 41.

equipment, was of value also in the interpretation of the experiment to the subjects and in determining artifact or extraneous electrical activity. The younger girls were very enthusiastic about seeing their muscle action upon a television like screen.

A satisfactory recording of muscle potential depends upon many things. Some of the more important considerations have to do with the transducer. The correct choice of the best electrode site; the selection of the most suitable type of electrode; the use of the most efficient attachment device and careful preparation of the skin cannot be over stressed.[1] Where and how far apart to place the electrodes is extremely important when the action of a particular muscle is being studied. It is generally considered best to place the electrodes over the center of the muscle in the proximity of the motor point. The location of the motor points for this study and the directions for locating the electrodes were provided by Davis.[2] The electrode placement was based upon measurements determined from bony landmarks upon the back and arm of the subject. Davis gave only one location for electrode placement for the study of the trapezius muscle. Fortunately the placement sites lay in the adductor

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[1]Davis, op. cit., pp. 24-25.

[2]Ibid., pp. 25-28.

area of this muscle, which is called Trapezius III by Rasch and Burke.[1] The large superficial muscle upon the posterior surface of the upper back covers the rhomboid, and these two muscles are the primary adductor muscles of the scapula which need strengthening to ameliorate the abducted position of the scapulae found in round shoulders.

Many types of internal and external electrodes were investigated for the electromyographic test. The selection was determined by the investigator to meet the needs of the specific problem being studied. E & M Electrodes[2] were selected since they were easily applied, maintained and provided satisfactory electromyographic readings.

Various methods of skin preparation were suggested by different authors; however, the directions of the E & M Company[3] and Davis[4] were generally followed after consultation with the members of the committee directing the study. The methods for the preparation of the skin are described in detail as part of the preparation of the subjects for the testing period in the following chapter.

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[1]Rasch and Burke, op. cit., pp. 151-154.

[2]These electrodes were available from the E & M Company which also supplied the double adhesive washers used to attach the electrodes. A sheet of instructions for electrodes application was provided by the company (Houston, Texas).

[3]Ibid.

[4]Davis, op. cit., pp. 25-28.

Calibration of the Monitor and Accessory Equipment for Testing

These procedures were performed before the subject arrived at the Human Performance Laboratory at Texas Woman's University. The temperature in the laboratory was maintained at approximately seventy-two degrees Fahrenheit. The monitor was turned on at least one half hour before the scheduled testing period to warm-up. After the specified time had elapsed, the auxiliary components, the oscilloscope and the electronic counter, were activated. A record of the full scale reading for one second was obtained from the electronic counter. This self-test was built into the monitor to indicate internal efficiency.[1]

In addition to the instrument self-test, another method of verification was utilized. This was calibration of the monitor by use of a Hewlett-Packard Low Frequency Function Generator Model 202A, and an Audio-Frequency Microvolter, Type 546-C manufactured by General Radio Company. The generator was set to function at 1000 Hz, while the microvolter produced fifty microvolts. The desired readout from the monitor and digital counter was forty-five microvolts when the full scale dial was set at .1 mv and the recording time was set at one second. The readout was

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[1]Integrating Bioelectric Monitor, Model 100, op. cit., p. 2.

recorded upon the data sheet, and the value was later multiplied by 1.111 to convert the average absolute value produced by the monitor to the root mean square value, which was the input used to calibrate the instrument. Errors in excess of one microvolt necessitated adjustment of the final reading for any subject tested to correct for instrument error. The equipment for independent calibration was then disconnected from the monitor.

After calibration the electrode lead was reattached to the monitor, and into the active lead circuit was placed a loop of copper wire; this caused a short circuit, resulting in no resistance. The purpose of this was to test for Output Offset Error. Output Offset Error originates in the output section of the monitor. In order to determine if there was an Output Offset Error large enough to distort the recorded value, two readings were necessary. This was because the Output Offset Error is not a function of the voltage, but is the result of amplification. The first recording was obtained with the maximum gain pattern of 100 mv; the test was repeated at the gain patter of 1.0 mv, which was used for the collection of all data for the present study. The difference in these two readings at the two test patterns represents the error of the output section of the monitor due to amplification. An error in excess of one microvolt would have been subtracted from each measurement; however, the Output Offset Error never reached this dimension.

After the instrumentation had been classified as operational the impedance of the subject was determined. Impedence may be defined as the opposition to the flow of alternating current.[1] Impedence, for the present study, would be primarily due to skin resistance. Proper skin preparation and electrode attachment limit impedence. It was necessary that impedence be less than 5,000 ohms; if not errors in voltage appear, thus, the skin preparation procedure was repeated if impedence measurement indicated more than the 5,000 ohm limit. To test for impedence the active cables leading from the subject were placed into the input cable leading to the monitor, which was set to record impedence, and the value was recorded for one second periods. The oscilloscope was also checked for artifacts in the impedence mode, and either a square or slightly rounded pattern with vertical line slope was obtained; if not, a check was made for possible causes of artifacts, and the correct patterns was seen before the test continued. Upon the completion of each of the described procedures the apparatus was found acceptable to utilize in the study.

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[1] R. C. Camishion, Basic Medical Electronics (Boston: Little, Brown and Company, 1964), p. 39.

Summary

The components necessary to conduct a quantitative electromyographic study were described and their operation as utilized for the present study specified. Chapter IV presents the procedures of the study.

CHAPTER IV

PROCEDURES OF THE STUDY

Introduction

The basic question underlying this investigation was: which of the exercises recommended by selected writers of books concerning posture and adapted physical education are the most effective for strengthening the trapezius muscle. The electromyographic technique was utilized to answer this question. In the preceding chapters, previous investigations pertinent to the various elements of the present study were discussed and the instruments utilized in the study described as a prelude to the establishment of procedures. This chapter was written to appraise the reader of the steps taken in the establishment of the basic design of the study.

After the subject--round shoulders, had been determined and the method--electromyography selected, it was necessary to develop a basic research design for the study. Information from all available documentary and human sources of data relevant to the present investigation was studied. One of the purposes of the survey of literature was to ascertain the available information concerning round shoulders.

and the scientific basis for that information. As part of the preliminary procedures a list of exercises recommended to ameliorate the postural condition of round shoulders was collected from sixteen different books. The list was subsequently revised to include only exercises recommended by authors who had published books about posture and adapted physical education since 1960; eleven books[1] met this criterion and contributed sixty-two exercises. The number of times a particular exercise was recommended and charted, and the basic elements stressed in the various exercises were determined. The exercises were grouped into categories according to the basic elements of the exercise and the best exercise in each category was ascertained by a pilot electromyographic study utilizing secondary school and college age students as subjects.

All except one of the eleven books considered round shoulders as a separate and unique condition; however, at times, the exercises were grouped and recommended for the amelioration of more than one condition. Most authors stressed the importance of several factors for the improvement of posture. The authors agreed that strengthening of the scapular adductors was needed to ameliorate the postural condition of round shoulders.

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[1]The eleven books are listed in Appendix I, p. 121.

Material in anatomy, kinesiology and physiology texts relevant to the present study was studied. The muscles listed as scapular adductors were the trapezius and rhomboid. The trapezius is the superficial adductor muscle and therefore the present study by surface electromyography is concerned primarily with that muscle. The rhomboid lies beneath the trapezius and since the body is a volume conductor and surface electrodes are not selective, the activity of the rhomboid muscle was noted to some degree by the electrodes placed upon the surface of the trapezius. For the same reason the synergistic effort of all parts of the trapezius was reported. Authorities differ as to the usefulness of the rhomboid in adduction. Physical educators tend to include the rhomboid as an adductor, but it seems to be the weaker of the adductors of the scapula, especially the rhomboid minor portion which is the part used for adduction.[1]

The Pilot Study

An extensive pilot study preceded the present investigation. During the pilot study the investigator determined, with the aid of the chairman of the study, the best means of utilizing the electromyograph in the present research design. Efficiency in the operation of the electronic apparatus and in the location and preparation of the electrode sites were

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[1]Rasch and Burke, op. cit., p. 156.

among the objectives of the pilot study. Volunteer adult and teen age subjects were utilized during all phases of the pilot study.

The sixty-five exercises suggested by the authors of the selected books were grouped into categories according to their basic elements. These categories are indicated by the identifying titles of the final twelve exercises. One category, hanging from an overhead bar, was deleted after consultation with the thesis committee. It was noted that none of the subjects in the pilot study could execute all of the hanging variations correctly. If this category of exercises were too difficult for the subjects involved in the pilot study it was believed that few, if any, of the round shouldered subjects for the final study would be able to perform them correctly; therefore they were not considered practical for inclusion.

The selection of the best exercise in each category was determined by the exercise which provided the consistently highest muscle action potential as demonstrated by the numerical figures obtained from the electronic counter during the pilot study. For the present study, it was assumed that the greater the muscle action potential recorded, the greater the tension elicited. The investigator eliminated exercises requiring complex equipment or assistance. This was done to insure the usefulness of the results obtained for all school situations.

The directions for the exercises to be given to the subjects for the performance of the test were established in the initial phase of the pilot study. Terminology and test procedures were modified when advisable during the pilot study. The directions, which also serve to describe the exercises finally selected were given in the following manner:

Exercise 1: Wand

Sit on a bench, and hold a wand overhead with the palms forward and the hands three feet apart. Slowly pull the wand down behind the head and shoulders, drawing the shoulder blades forcefully together. Keep the head well back and the stomach retracted.[1*]

Exercise 2: Wall Press

Sit cross-legged on the floor with the back flat against the wall. Extend the arms overhead against the wall, shoulder-width apart and palms forward. Keeping the stomach retracted and the head against the wall, bend the elbows and

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[1] Katherine F. Wells, Posture Exercise Handbook (New York: Ronald Press, 1963), p. 64.

*Note that the references cited for each exercise are not exact quotations because common elements were extracted from similar exercises suggested by all eleven authors and restated for ease of explanation.

slowly draw the arms down along the wall, pulling the shoulder blades together as forcefully as possible. When the hands have reached the shoulder level, hold the position.[1]

Exercise 3: Arm Circling

Sitting on a bench, feet on floor toeing forward, arms side horizontal, palms up, describe four small circles backward. Repeat making four larger circles backward. Continue alternating small and large circles until time is called. The small circles should be approximately three to four inches in diameter; the larger circles eleven to twelve inches in diameter. Keep upper back flat and shoulder blades together.[2]

Exercise 4: Scapular Pinch with Arm Rotation

Sit, feet crossed, knees separated, arms side horizontal, palms down. Pinch shoulder blades together. (Do not raise or pull back on arms or shoulders. Limit movements to scapulae only.) Turn palms upward and continue rotation of palms until time is called.[3]

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[1] *Ibid.*, p. 269.

[2] Lowman and Young, *op. cit.*, p. 273.

[3] Logan, *op. cit.*, p. 222.

Exercise 5: Prone Arch from Non-Support

Assume a prone position upon the table with the upper body, from the waist up, not supported, with the feet anchored and the hands clasped behind the head. The trunk is then raised as high as possible, with elbows kept back. Hold the position until time is called.[1]

Exercise 6: Active Chest Stretch

Sitting position on bench, knees bent and feet flat, hands behind head with elbows out, chin held in, and head held high; partner places knee against upper back and forces elbows backward, stretching chest muscles; subject holds starting position and assists the movement, thus contracting upper back muscles.[2]

Exercise 7: Back Arch

Lying on the back with left leg straight and the right leg bent with the hands clasping the leg, start the exercise. Pull the knee close to the body, lift the head, and touch the forehead to the knee. Return the head to the mat. Keeping the knee clasped close to the body and the

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[1] Logan, op. cit., p. 222.

[2] Clarke and Clarke, op. cit., p. 204.

chin tucked in, press the back of the head down against the mat and arch the upper back slightly from the mat. Hold.[1]

Exercise 8: Push Back Against Wall

Sit cross-legged with the head and back flat against the wall and the arms bent at shoulder height with the palms facing the chest, fingertips touching and the elbows against the wall. Keeping the head and spine against the wall, press the elbows back with as much force as possible.[2]

Exercise 9: Head Resistance

Lying on back, arms out to side, palms down, knees flexed, feet spread, raise hips and arch back so that shoulders are off mat, supporting weight on feet, hands and back of head. Modified wrestler's bridge.[3]

Exercise 10: Trunk Extension

Sit on the heels with the knees on the floor and the trunk bent forward until the chest rests on the thighs; arching of the back with backward moving of the head until the trunk is a little above horizontal. The arms are

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[1]Wells, Posture Handbook, p. 68.

[2]Ibid., p. 47.

[3]Daniels and Davies, Adapted Physical Education, p. 130.

extended at the sides and rotated outward when . . . the spine is extended.[1]

Exercise 11: Pull Resistance

Correct sitting position on chair facing the wall with pulleys, with the arms extended sideward at shoulder height and the hands grasping the handles. Slowly move the arms backward, keeping them at shoulder height.[2]

Exercise 12: Prone Lateral Raise of Weights

A prone position is taken on a bench, and the hands grasp dumbbells on the floor to each side of the body. The weights are lifted toward the ceiling as far as possible, keeping the arms straight. Hold. (Chin should remain on the bench.[3]

Verbal direction, in addition to the basic exercise description, were frequently necessary. An initial trial attempt of each exercise was provided to insure proper administration.

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[1]Rathbone and Hunt, op. cit., p. 176.

[2]Mueller and Christaldi, op. cit., pp. 139-140.

[3]Hollis F. Fait, Special Physical Education: Adapted, Corrective, Developmental (2nd ed., Philadelphia: W. B. Saunders Company, 1966), pp. 280-281.

Selected exercises from among the twelve finally accepted were administered to three subjects ten consecutive times to find the number of repetitions required for a reliable measurement for ranking the exercises. The mean scores based upon three, six, and ten repetitions were compared. Since no participants scores changed the derived ranking of the exercises with more than three repetitions, that number was determined to be reliable by empirical judgement.

Test-retest reliability was correlated after administering the series of twelve exercises to seven individuals on two different days. A Rank Order Coefficient of Correlation for Reliability was computed for each subject. As the coefficients of correlation obtained for each individual differed considerably from the others in the sample, the method described by Guilford using the Fisher "z" coefficient conversion was utilized to combine them.[1] A final coefficient of correction for reliability of .85 was obtained in this manner.

Selection of Subjects for the Present Study

After a thorough investigation of the literature relating to posture and to the condition of round shoulders

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[1] J. P. Guilford, Fundamental Statistics in Psychology and Education (3rd ed., New York: McGraw-Hill Book Company, Inc., 1956), p. 265.

specifically, subjects were selected primarily upon the criterion of Charles Leroy Lowman, Orthopedic Physician and postural authority, who maintains that:

> The normal scapular interspace, except in very heavily muscled and stout persons, measures about 3 inches. Therefore, if the stretch amounts to from 3 to 5 inches, it may be thought of as second degree or moderate, and 5 inches or over is considered third degree or severe.[1]

A scapular separation of more than three inches was accepted as indicative of round shoulders. This measurement is an obvious gauge of the strech of the shoulder adductor muscles which were the muscles pertinent to the present study. All subjects met the criterion of a scapular separation in excess of three inches. The subjects from the elementary school age group had a scapular separation range of from four to five inches with a mean separation of 4.321. The secondary school age group had a scapular separation range of from 4.75 to 6.26 inches with a mean separation of 5.464. College students measured from 5.5 to 6.5 inches between the scapulae with the mean separation being 5.893.

All twenty-one of the subjects were female students and none of the subjects were extremely obese. The research design utilizing the three school age groups was developed in order to ascertain the difference in rating of exercises by electromyography among the different age levels.

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[1]Lowman and Young, <u>op. cit.</u>, p. 108.

The youngest participants were to be in the fourth through sixth grades in September of 1968; their ages varied from 9 to 12 years. The secondary school participants were to be either ninth or tenth graders in the fall of 1968; they were either 14 or 15 years of age. The university women tested had been classified as sophomores through seniors during the spring semester of 1968 and they were presently enrolled in summer classes; their ages varied from 19 to 22 years.

Collection of Data

The volunteer subjects who met the criterion for round shoulders were scheduled for a testing period. Each subject was asked to wear a bathing suit for the test. While the subject stood in a relaxed posture with her upper limbs hanging relaxed at her sides, her scapular separation was measured to the nearest one-fourth inch at the lower angle of those bones.

Realizing that the subjects might be uneasy in the strange setting and that the equipment might frighten them, the investigator attempted to maintain a relaxed testing situation. The subject was told that she might try the bicycle ergometer; the seat height was excellent for making measurements upon the posterior shoulder area. The method followed for the placement of the electrodes was that described by Davis.[1] Each step of the measurement and preparation procedure was explained to the subject before it was carried out. The marking pen was shown to her, and she was asked to place her fingertips so that they touched her clavicles and hold this position for the marking phase of the procedure. When the spinous processes of the seventh cervical and first three thoracic vertebrae were difficult to locate, the subject was asked to bend her head forward; the spinous process was located in this manner, and then the investigator kept her finger upon that process as the subject assumed the correct position again--this was a necessary procedure because the skin tightens as the subject bends forward, and the marking would not be correct if made when the skin was stretched. The right arm of the subject was moved back and forth so that the head of the humerus could be located as accurately as possible, and that location was marked. The measurements for the electrodes were made as follows: the upper electrode was placed one and five-eighths inches to the right from a point halfway between the spinous processes of the seventh cervical and first thoracic vertebrae. The lower electrode was located by determining with a measuring tape a point halfway between the head of the humerus and the midpoint between the second and third thoracic vertebrae.

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[1]Davis, op. cit., pp. 25-28.

The boney area of the wrist was selected for the reference electrode.

The use of alcohol to cleanse the surface oil from the skin was explained to the subject, and the ground or reference site upon her wrist was cleansed first with the cotton pad saturated in alcohol; the two electrode areas on the back were next rubbed carefully, and then the excess markings of the dry brush pen upon the back were removed. The electrode markings had to be darkened after the area was treated with alcohol.

The function of the sandpaper (Extra Fine Flint Paper) in removing the horny outer layer of skin was next explained to the subject, and she was given a piece of sandpaper and asked to sand the wrist area while the investigator sanded the back area. This procedure was followed by both persons until the respective areas were pink.

The ground or reference electrode was shown to the subject, and the general functions of the electrodes was explained as similar to microphones which will pick up the sounds from her muscle and record them upon the television like screen. The electrodes had been prepared before the subject arrived at the laboratory in the normal manner. After showing the ground electrode to the subject, the investigator attached this electrode to the prepared area upon the left wrist of the subject. The two active electrodes were attached to the skin above the trapezius muscle in the same way. Some difficulty was experienced in keeping the electrodes secured to the skin of the subject, and when necessary, two inch elastic adhesive tape was used to hold the electrode firmly in place.

The subject was then tested for impedance. A value of 5,000 ohms or less for a one second digital reading was required. If the ohmic value was not satisfactory, the electrodes were removed and the skin preparation procedure was repeated.

After testing for impedance the subject was asked to stand in a relaxed manner with her arms hanging at her sides, and the pattern upon the oscilloscope was explained to her. The investigator next placed her hand between the scapula of the subject and asked her to pinch the hand with her back muscles; the increased activity upon the oscilloscope was noted. The investigator explained that many of the exercises would call for this type of movement.

A rotation plan was utilized so that the exercises performed first by one subject was designated as the last exercise for the next subject. This procedure was used to negate the influence of a set order of exercises for all subjects upon the muscle action potentials.

The subject was asked to try to follow the directions that were given as faithfully as possible. She was told that all exercises would be for a ten second period and that she would be given the signal "Ready" in preparation and the word "Go" when the exercise was to be performed and the word "Stop" when the time period was completed.

Each exercise was explained to the subject, and she was asked to try the exercise. Needed modifications of her movements were explained, and any questions were answered. The testing followed with three repetitions for each of the twelve exercises; the subject was given a ten second rest period between each repetition.

Time was allowed between the different exercises to avoid the factor of fatigue. This time period was not arbitrarily set. The procedure described above was repeated until all twelve exercises were completed. Upon completion of the testing, the electrodes were carefully removed and washed. The excess electrode paste which remained upon the skin of the subject was removed with a tissue, and lotion was applied to the areas where the electrodes had been placed. Each subject was thanked for her participation.

During the testing procedure, a recorder assisted the investigator. The assistant was responsible for recording the digital readout from the electronic counter at the end of the ten second exercise period. She gave the command

"Stop" if the investigator was observing the subject at the end of the testing period. The assistant further helped during the test by having any necessary equipment for the following exercise ready. As the starting exercise was different for each subject, this facilitated the testing period.

The equipment required for the exercises was as follows:

Exercise 1--bench, wand.

Exercise 2--mat, smooth wall.

Exercise 3--bench.

Exercise 4--nothing.

Exercise 5--table, bench, anchor for feet.

Exercise 6--bench, assistant.

Exercise 7--mat.

Exercise 8--mat, smooth wall.

Exercise 9--mat.

Exercise 10--mat.

Exercise 11-chair, spring type wall pulleys.

Exercise 12--bench, two dumbbells each of three pounds weight.

The recorder placed upon the individual data sheet for each subject the information required.[1] In addition to the subjects name and age, and data pertaining to the callibration

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[1]See Appendix II, page

of the machine, the average absolute value obtained from the electronic counter for each exercise trial was recorded.

Correction for noise and/or Output Offset Error would normally be the procedure to follow collection of the data for each subject. All of the determined corrections were found to be minor, less than one microvolt, therefore they had no bearing upon the authenticity of the recordings and thus, there was no need to apply any correction to the test data collected.

After each test period, the data from each subject were treated in the following manner. The scores for the three repetitions of each exercise were totaled, and the mean was obtained. This mean represented the mean of the average absolute value of the muscle action potential for each participant. Rankings for each individual of the twelve exercises were obtained from these means.

Procedures Followed in the Statistical Treatment of Data

A study of previous electromyographic investigations concerning the treatment of data indicated that most of the previous data had been treated in a qualitative manner by the researchers interpreting the electromyograms. Other investigators have arbitrarily quantified their data by establishing some means of evaluating the height or number of muscle action potential peaks. The present study utilized quantitative electromyographic techniques and therefore obtained data amenable to statistical treatment.

Statistical Treatment of Data

Analysis of the data involved determining the relative agreement among the rankings derived from the muscle action potential scores of the individual participants and of the three different age groups as they performed the twelve exercises. The coefficient of concordance was selected as the appropriate statistical treatment. The coefficient of concordance, *W*, was developed by Kendall as a descriptive measure of the agreement or concordance among two or more sets of ranks.[1]

In describing the coefficient of concordance Edwards states that:

> The coefficient of concordance . . . can only be positive in sign and ranged from 0 to 1. It will be 1 when the ranks assigned by each judge [or participant] are exactly the same as those assigned by the other judges [participants] and it will be 0 when there is maximum disagreement among the judges.[2]

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[1]George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, Inc., 1959), pp. 185-186.

[2]Allen L. Edwards, Statistical Methods for the Behavioral Sciences (New York: Holt, Winston and Winston, 1961), p. 402.

Ferguson notes that complete disagreement cannot occur with more than two sets of ranks.[1]

The concordance among individual participants within an educational level subgroup and within the total group was compared; the concordance of subgroup rankings was also compared to the total group rankings by this technique. The significance of the concordance between participants in various combinations was tested by means of Chi Square. Edwards[2] explains that the coefficient of concordance and Chi Square are closely related, illustrating with the formulae,

$$W = \frac{X_r^2}{m(n-1)} \qquad \text{and} \qquad X_r^2 = (W)(m)(n-1)$$

The latter formula was used for finding Chi Square to test the significance of the coefficient of concordance. Using the obtained score, a Table of Chi Square[3] was entered with n-1 degrees of freedom (11), and a Chi Square equal to 24.725 or greater was found to be significant at the .01 level of confidence.

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[1]Ferguson, op. cit., p. 187.

[2]Edwards, op. cit., p. 500.

[3]Ibid.

The Duncan's Range Test[1] was utilized to ascertain if a significant difference existed among the muscle action potential mean scores obtained for the twelve exercises by the seven participants for the same educational level and among the mean scores for the entire group of twenty-one participants.

Summary

In this chapter the procedures for the present study were described. The preliminary procedures were established for the selection of subjects, exercises and test administration. A survey of literature pertinent to the study yielded sixty-five exercises which were narrowed to the exercises reported in the final study by a pilot electromyographic study; testing procedures were developed as a portion of the pilot investigation.

For the final study, twelve exercises were performed by twenty-one subjects, evenly divided between three educational levels. The electromyographic data for these exercises were obtained from a ten second recording of the Newport Bioelectric Integrating Monitor. The ranking of the twelve exercises obtained from the scores of each subject

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[1] F. J. McGuigan, Experimental Psychology (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1960), pp. 172-187.

was based upon the mean of three repetitions of each of the exercises. The actual procedures for the collection of data were described, and finally the procedures followed in the statistical treatment of the data presented. In the next chapter, the results of the statistical treatment of data are reported. Tabular and narrative forms are used to present an analysis of the data.

CHAPTER V

PRESENTATION OF THE FINDINGS AND INTERPRETATION OF THE DATA

Introduction

In this chapter, the data collected during the controlled experimental situation and the statistical analysis are presented. The previous chapter considered the procedures for the collection and analysis of the data discussed in this chapter. Briefly, a survey of literature provided a number of exercises recommended for the amelioration of the postural condition of round shoulders. By means of a pilot study, the best exercise in each of twelve categories was selected by an electromyographic technique. During the pilot study, acceptable testing procedures were developed, and the reliability of the present technique for ranking exercises, based upon the muscle action potential, was found to be satisfactory.

Twenty-one subjects from three different educational levels provided the data upon which these findings are based. The mean age for the elementary school age children was 9.9 years. The mean age for the secondary school students and for the college level subjects was 14.3 and 20.3 years respectively. The mean score for three repetitions of each of twelve exercises was obtained and ranked for each individual participant based upon the muscle action potential of that subject as she performed the exercise. The muscle action potentials were recorded with an electronic counter, an auxiliary piece of equipment attached to the electromyographic monitor which provided a numerical readout of physiologic phenomena occurring in the muscle studied.

Method of Data Presentation

The data were compared in several ways within and among the three educational levels, as well as for the total group based upon the exercise ranking for each individual according to the mean performance of that participant. Upon each data sheet,[1] the total muscle action potentials for three consecutive repetitions of each exercise were recorded, and the mean performance for that exercise was then computed. The exercise rankings by each participant were based upon the mean muscle action potentials for each of the twelve exercises. The group mean for the muscle action potential of each exercise was then tabulated, and the group ranking was based upon these data. In like manner, the mean of the muscle action potential for each exercise for the total participants was obtained, and the ranking of the exercises by the total group was derived.

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[1] Appendices II, page, p. 123.

In the previous chapter the statistical techniques used to analyze the data were described. The agreement of the rankings of the exercises derived from the muscle action potential scores of the participants was tested by using the coefficient of concordance with a Chi square test of significance. The significance of the difference between the muscle action potential readings for the twelve exercises was tested by Duncan's Range Test.

Table 1, page 84, presents the mean and rank of the muscle action potential of each exercise for each of the three groups. The mean was determined by totaling the muscle action potential scores for each exercise, then dividing by twenty-one; the division represented three repetitions of each exercise by the seven participants of each age group. The coefficient of concordance (w) representing the degree of agreement in the ranking among the three groups was .919 with a Chi square (x^2) value of 30.32. This was significant at the .01 level of confidence. These data, statistically treated in this manner, indicate the selected exercises recommended to ameliorate the postural condition of round shoulders as measured by the electromyographic technique employed for this study may be ranked with respect to muscle action potential from the scores of the three educational level subgroups with a very high level of confidence.

Table 1

MEAN MUSCLE ACTION POTENTIALS, AND RANK, FOR EACH SUBGROUP AND THE COEFFICIENT OF CONCORDANCE FOR THE THREE GROUPS

Number	Exercises*	Subgroup					
		Elementary		Secondary		College	
		MAP	Rank	MAP	Rank	MAP	Rank
1	Wand	110	10	132	11	137	11
2	Wall Press	183	5	271	5	224	4
3	Arm Circling	175	6	230	8	192	7
4	Scapular Pinch	172	7	194	9	197	6
5	Prone Arch from Non-support	122	9	235	7	163	10
6	Active Chest Stretch	61	12	141	10	174	8
7	Back Arch	81	11	96	12	92	12
8	Push Against Wall	229	3	303	4	328	2
9	Head Resistance	210	4	312	3	219	5
10	Trunk Extension	169	8	269	6	166	9
11	Pull Resistance	375	2	440	1	397	1
12	Prone Lateral Raise of Weights	394	1	388	2	270	3
		N=7		N=7		N=7	

$W = .92$

$X^2 = 30.32$ ($p<.01$)

*The actual exercise represented by the number on this table may be found by a similar number in Chapter IV, pages 63 to 67.

Table 2, page 86, contains the ranking of the twelve exercises based upon the muscle action potential recordings of each participant and the ranking for each educational level determined by the mean of the subgroup rank total. The elementary education subjects evidenced the greatest consistency in recorded muscle action potential. Upon inspection of the ranked mean muscle action potentials exercise number twelve, Prone Lateral Raise and number eleven, Pull Resistance, received either a first or second ranking by all of the subgroup participants. Exercises number eight, Push Against Wall, number nine, Head Resistance, and number two, Wall Press, were ranked third, fourth, and fifth, respectively. The individual rankings of these exercises varied from third to eighth position. Ranked sixth, seventh, and eighth were exercises number four, Scapular Pinch, number three, Arm Circling, and number ten, Trunk Extension; the individual ranked muscle action potential of these exercises varied from third to tenth place. The ninth ranked exercise, number five, Prone Arch, appeared always among the lower ranks, varying from sixth through eleventh position. The three least desirable exercises were number one, Wand, ranked tenth, number seven, Back Arch, ranked eleventh, and number six, Active Chest Stretch, ranked twelfth. These exercises varied from eighth to

Table 2

RANKINGS BASED UPON THE MUSCLE ACTION POTENTIAL RECORDINGS OF EACH PARTICIPANT FOR THE TWELVE EXERCISES AND THE RANKING OF EACH EDUCATIONAL LEVEL GROUP FOR THE EXERCISES*

Number	Exercise	Elementary Participants								Secondary Participants								College Participants							
		A	B	C	D	E	F	G	Total Group	A	B	C	D	E	F	G	Total Group	A	B	C	D	E	F	G	Total Group
1	Wand	8	9	10.0	10	9	12	10	10	11	11	10	11	10	10	11	11.0	7.5	11	9.0	12	11	6	9	11
2	Wall Press	5	8	5.0	4	5	7	5	5	2	5	7	9	7	6	4	5.5	9.0	5	1.0	4	9	9	7	5
3	Arm Circling	9	6	7.5	7	7	6	4	7	8	1	8	4	6	8	10	7.0	11.0	9	4.0	9	4	7	10	8
4	Scapular Pinch	10	7	3.0	6	4	9	7	6	5	8	9	7	9	9	8	9.0	10.0	7	5.0	10	5	5	4	6
5	Prone Arch from Non-support	6	11	7.5	12	8	10	9	9	7	7	6	5	8	7	6	8.0	6.0	6	10.5	8	8	10	6	9
6	Active Chest Stretch	12	12	11.0	11	12	8	12	12	9	9	11	10	12	12	9	10.0	5.0	2	8.0	11	7	11	8	7
7	Back Arch	11	10	12.0	9	11	11	11	11	12	12	12	12	11	11	12	12.0	12.0	12	10.5	7	12	12	12	12
8	Push Against Wall	4	3	4.0	5	6	5	3	3	4	6	5	3	5	3	3	4.0	2.0	3	2.0	3	2	3	2	2
9	Head Resistance	3	4	6.0	3	3	4	8	4	3	2	4	2	3	5	7	3.0	3.0	4	7.0	6	10	4	3	4
10	Trunk Extension	7	5	9.0	8	10	3	6	8	10	10	1	8	4	2	5	5.5	7.5	8	12.0	5	6	8	11	10
11	Pull Resistance	2	1	1.0	1	2	2	2	2	1	3	3	1	2	1	2	1.0	1.0	1	3.0	1	1	1	1	1
12	Prone Lateral Raise of Weights	1	2	2.0	2	1	1	1	1	6	4	2	6	1	4	1	2.0	4.0	10	6.0	2	3	2	5	3

*This table is to be read in the following manner: Elementary participant A ranked exercise number 1, the Wand exercise, eighth and exercise number two, the Wall Press, fifth, etc.

twelfth position. In the elementary ranking, the two highest and three lowest exercises appear to be the most consistent among the rankings. This consistency probably indicates a true difference in the ability to develop tension in the shoulder area and a valid rank differentation in exercise value.

For the secondary school participants, the highest ranked exercise was number eleven, Pull Resistance, which varied from first to third position. The exercise in the second position, number twelve, Prone Lateral Raise, received individual rankings from one to six. The use of heavier or lighter weights, which this exercise requires could have obviously altered the muscle action potential and thus the possible value of the exercise. The exercises ranked third and fourth based upon the muscle action potential of the high school group were number nine, Head Resistance, and number eight, Push Against Wall, respectively; the individual ranking varied from second to seventh. Great variation was evidenced in the individual positions obtained by the exercises ranked fifth through seventh. Fifth and sixth positions, exercises number ten, Trunk Extension, and number two, Wall Press, were ranked of equal value. The subjects ranked exercise number three, Arm Circling, in seventh position. The exercises in eighth and ninth position were number five, Prone Arch, and number four, Scapular Pinch, respectively; their individual ranking ranged from fifth through ninth. The three lowest ranked exercises were exercises number six, Active Chest Stretch, number one, Wand, and number seven, Back Arch. The individual ranking for these three exercises varied from ninth through twelfth. For the secondary participants only the top and bottom three ranked exercises appear decisive. The differences between the extreme rankings probably indicate real differences in the value of these exercises.

The ranking obtained from the muscle action potential of the college level participants, with one exception, placed exercise number eleven, Pull Resistance, in first position. The second choice was exercise number eight, Push Against Wall, which was ranked from the recording of the muscle action potential elicated by the college age subjects either in second or third position. It was often noted that the group rankings of third through eighth position were based upon divergent individual rankings with a variability of six positions within the group. The final four group rankings were rated in the lower positions by every subject.

Table 3, page 89, displays the total of the rankings derived from the muscle action potential recordings of all twenty-one participants, with each participant considered independently. As these figures represent the total of the individual rankings of the twenty-one raters shown upon

Table 3

COMBINED RANKINGS OF THE TWELVE SELECTED EXERCISES BASED UPON THE MUSCLE ACTION POTENTIAL READINGS OF TWENTY-ONE PARTICIPANTS WITH EACH SUBJECT CONSIDERED INDEPENDENTLY

Number	Exercise*	Total of Value Ranking*	Rank
1	Wand	207.5	11.0
2	Wall Press	123.0	5.0
3	Arm Circling	145.5	6.5
4	Scapular Pinch	147.0	8.0
5	Prone Arch from Non-support	164.0	9.0
6	Active Chest Stretch	202.0	10.0
7	Back Arch	234.5	12.0
8	Push Against Wall	76.0	3.0
9	Head Resistance	94.0	4.0
10	Trunk Extension	145.5	6.5
11	Pull Resistance	33.0	1.0
12	Prone Lateral Raise of Weights	66.0	2.0
		N=21	

*The total value of ranking was achieved by summating the ranked value of each of the twenty-one participants.

Table 2, page 86, it is natural that the coefficient of concordance of the total group would fall between the highest and lowest coefficient of concordance of the three groups. The rankings of the different tables presented are closely allied, but exercise three, Arm Circling, is ranked less important by the three subgroups than by the total group, illustrating individual and subgroup variation. Exercise number eleven, Pull Resistance, was ranked highest. This exercise was first in the secondary and college groups and second in the elementary group. Exercise number twelve, Prone Lateral Position, was ranked second on the combined rankings of subjects when considered independently as it was for the high school group; it was ranked first for the elementary age students and third from the recordings of college students. Exercises number eight, Push Against Wall, and number nine, Head Resistance, were ranked third and fourth, respectively; they had been ranked second through fourth in the three educational level group rankings. Exercise number seven, Back Arch, was ranked lowest, just as it had been by both the high school and college groups; it was next to the poorest among the elementary school subjects. Exercise number two, Wall Press, maintained the middle ranking as it had in all groups. Exercise number five, Prone Arch, was in ninth position, as it had been rated from scores of elementary and university students;

the high school subjects placed it eighth. Exercise number six, Active Chest Stretch, was ranked tenth, having varied from seventh through twelfth position in the three group rankings. Exercise number four, Scapular Pinch, was ranked eighth, having ranged from sixth to ninth position.

Table 4, page 91, lists the coefficient of concordance and Chi square value computed for the data presented in Tables 2 and 3, pages 86 and 89, respectively. The elementary group evidenced the highest coefficient of concordance, .82 with a Chi-square value of 62.83 ($p<.01$). The secondary group had a concordance of .74 and a Chi square value of 57.12 ($p<.01$). The college group demonstrated the lowest concordance, .60, with a Chi square value of 45.82 ($p<.01$). All group concordances were significant at the .01 level of confidence, as was the total concordance ($w=.65$) with a Chi square value of 151.14 ($p<.01$).

Table IV

COEFFICIENT OF CONCORDANCE FOR RANKED EXERCISES BY EDUCATIONAL LEVEL AND TOTAL GROUP

	Elementary	Secondary	College	Total
W^2	.82	.74	.60	.65
X^2	62.83*	57.12*	45.82*	151.14*

*$p<.01$ = 24.72

Because the coefficient of concordance is concerned with relationships, the standards suggested by Barrow and McGee[1] for interpretation of coefficients of correlation were deemed appropriate. The coefficient of concordance for the elementary group (.82) is very good while the secondary age level (.74) was quite acceptable. The college age participants obtained a coefficient of concordance (.60) that would be considered questionable by the Barrow and McGee Standard. The coefficicient of concordance (.65) obtained by the entire group of twenty-one raters considered independently is of questionable value in the interpretation of the effectiveness of the twelve selected exercises according to Barrow and McGee's Standards.

Table 5, page 93, displays the significant differences among the twelve exercises performed by the seven elementary school age subjects. The exercise rankings from which the table was derived are presented in the right hand column in order that the more effective exercises can be ascertained upon inspection of the table.

For the elementary educational level the highest ranked exercise, Prone Lateral Raise, was superior to Active Chest Stretch, and Back Arch at the .01 level of significance. Pull Resistance, the second highest ranked exercise, was significantly better than Active Chest Stretch at the .01

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[1]Harold Barrow and Rosemary McGee, A Practical Approach to Measurement in Physical Education (Philadelphia: Lea and Febiger, 1966), p. 42.

Table 5

DUNCAN'S RANGE TEST FOR THE TWELVE EXERCISES PERFORMED BY ELEMENTARY EDUCATIONAL LEVEL GIRLS*

Number	Exercise	1	2	3	4	5	6	7	8	9	10	11	12	Rank
1	Wand													10
2	Wall Press													5
3	Arm Circling													6
4	Scapular Pinch													7
5	Prone Arch from Non-support													9
6	Active Chest Stretch											.01	.01	12
7	Back Arch											.05	.01	11
8	Push Against Wall													3
9	Head Resistance													4
10	Trunk Extension													8
11	Pull Resistance						.01	.05						2
12	Prone Lateral Raise of Weights						.01	.01						1

*This table should be read in the following manner: Exercise number seven, Back Arch, differs from exercise number eleven, Pull Resistance, at the .05 level of significance and to exercise number twelve, Prone Lateral Raise of Weights, at the .01 level of significance. Rank 1 is high. A description of the twelve exercises may be found in Chapter IV, pages 63 to 67.

level of significance, and it was superior to Back Arch at the .05 level of significance.

Table 6, page 95, contains the same type of information described for the previous table but for the secondary participants. The highest ranked exercise for this group was Pull Resistance, which differed significantly from the following exercises: Wand, Scapular Pinch, Active Chest Stretch, and Back Arch at the .01 level of significance. The Pull Resistance exercise was superior to the Wall Press, Arm Circling, and Trunk Extension at the .05 level of significance. The second highest ranked exercise was the Prone Lateral Raise of Weights and it differed from Back Arch at the .01 level of significance and from the following exercises at the .05 level of significance: Wand, Active Chest Stretch, and Head Resistance. The third ranked exercise, Head Resistance, was superior to the Wand Exercise, the Active Chest Stretch, and the Back Arch exercises at the .05 level of significance. The Push Against Wall exercise which ranked fourth and the Wall Press exercise which ranked fifth, were both better than the Back Arch exercise at the .05 level of significance as was the sixth ranked exercise, Trunk Extension. The effectiveness of the Prone Arch exercise was not significantly different from any other exercise.

Table 6

DUNCAN'S RANGE TEST FOR THE TWELVE EXERCISES PERFORMED BY SECONDARY EDUCATIONAL LEVEL GIRLS*

Number	Exercise	1	2	3	4	5	6	7	8	9	10	11	12	Rank
1	Wand									.05		.01	.05	11
2	Wall Press							.05				.05		5
3	Arm Circling											.05		8
4	Scapular Pinch											.01		9
5	Prone Arch from Non-support													7
6	Active Chest Stretch									.05		.01	.05	10
7	Back Arch		.05						.05	.05	.05	.01	.01	12
8	Push Against Wall							.01						4.
9	Head Resistance	.05					.05	.05					.05	3
10	Trunk Extension							.05				.05		6
11	Pull Resistance	.01	.01	.01	.05		.01	.01			.05			1
12	Prone Lateral Raise of Weights	.05					.05	.01		.05				2

*This table should be read in the following manner: Exercise number one, Wand, differs from exercise number nine, Head Resistance, and exercise number twelve, Prone Lateral Raise of Weights, at the .05 level of significance and to exercise number eleven, Pull Resistance, at the .01 level of significance. Rank 1 is high. A description of the twelve exercises may be found in Chapter IV, pages 63 to 67.

Table 7, page 97, includes the same information as Table 6, page 95, and Table 5, page 93, but for the college level participants. The Pull Resistance exercise obtained the highest ranking from this group. The muscle action potential score for this exercise differed from the following exercises at the .01 level of significance: Wand, Arm Circling, Scapular Pinch with Arm Rotation, Prone Arch from Non-support, Active Chest Stretch, and Trunk Extension. The Pull Resistance differed from the Wall Press and Trunk Extension at the .05 level of significance. The Push Back Against Wall exercise was ranked second by this group and it was better than the Back Arch exercise at the .01 level of significance, and better than the Wand, the Prone Arch from Non-support, the Active Chest Stretch, and the Trunk Extension exercises at the .05 level of significance. The Prone Lateral Raise of Weights exercise ranked third for the college participants, but it was superior only to the Back Arch exercise at the .05 level of significance.

Table 8, page 98, contains the significant differences for the means of the twelve exercises performed by the entire group of twenty-one participants. Ranked first was the Pull Resistance exercise which was superior only to the Push Against Wall exercise at the .01 level of significance. The Pull Resistance exercise was superior to the following exercises at the .05 level of significance:

Table 7

DUNCAN'S RANGE TEST FOR THE TWELVE EXERCISES PERFORMED BY COLLEGE EDUCATIONAL LEVEL GIRLS*

Number	Exercise	1	2	3	4	5	6	7	8	9	10	11	12	Rank
1	Wand								.05			.01		11
2	Wall Press											.05		4
3	Arm Circling											.01		7
4	Scapular Pinch											.01		6
5	Prone Arch from Non-support								.05			.01		10
6	Active Chest Stretch								.05			.01		8
7	Back Arch								.01			.01	.05	12
8	Push Against Wall	.05				.05	.05	.01			.05			2
9	Head Resistance											.05		5
10	Trunk Extension								.05			.01		9
11	Pull Resistance	.01	.05	.01	.01	.01	.01	.01		.05	.01			1
12	Prone Lateral Raise of Weights							.05						3

*This table should be read in the following manner: Exercise number one, Wand, differs from exercise number eight, Push Back Against Wall, at the .05 level of significance and to exercise number eleven, Pull Resistance, at the .01 level of significance. Rank 1 is high. A description of the twelve exercises may be found in Chapter IV, pages 63 to 67.

Table 8

DUNCAN'S RANGE TEST FOR THE TWELVE EXERCISES PERFORMED BY ALL TWENTY-ONE PARTICIPANTS*

Number	Exercise	1	2	3	4	5	6	7	8	9	10	11	12	Rank
1	Wand								.05			.05	.05	10
2	Wall Press							.01				.05		5
3	Arm Circling							.01				.05	.01	7
4	Scapular Pinch											.05	.01	8
5	Prone Arch from Non-support											.05	.05	9
6	Active Chest Stretch								.05			.05	.05	11
7	Back Arch		.01	.01					.05	.01	.01	.05	.05	12
8	Push Against Wall	.05					.05	.05				.01		3
9	Head Resistance							.01				.05		4
10	Trunk Extension											.05	.01	6
11	Pull Resistance	.05	.05	.05	.05	.05	.05	.05	.01	.05	.05			1
12	Prone Lateral Raise of Weights	.05		.01	.01	.05	.05	.05			.01			2

*This table should be read in the following manner: Exercise number two, Wall Press, differs significantly from exercise number seven, Back Arch, at the .01 level of significance and to exercise number eleven, Pull Resistance, at the .05 level of significance. Rank 1 is high. A description of the twelve exercises may be found in Chapter IV, pages 63 to 67.

Wand, Wall Press, Arm Circling, Scapular Pinch, Prone Arch from Non-support, Active Chest Stretch, Back Arch, Head Resistance, and Trunk Extension. The second ranked exercise, Prone Lateral Raise, was superior to the Arm Circling exercise, the Scapular Pinch exercise, and the Trunk Extension exercise at the .01 level of significance and to the Wand exercise, the Prone Arch exercise, the Active Chest Stretch exercise, and the Back Arch exercise at the .05 level of significance. In third position, the Push Against Wall exercise was significantly better than the Wand exercise, the Active Chest Stretch exercise, and the Back Arch exercise at the .05 level of significance. The fourth and fifth ranked exercises, Head Resistance, and the Wall Press, respectively, were both superior to the Back Arch exercise at both the .01 level of significance. The sixth ranked exercise, the Trunk Extension, was not significantly superior to any exercise, while the Arm Circling exercise was superior to the Back Arch exercise at the .01 level of significance.

An analysis of these data tend to support earlier observation that the significant differences in the muscle action potential produced by these exercises were between the exercises ranked first and second and the other exercises. From the results for the elementary subjects the two highest exercises were significantly more effective than the two lowest ranked exercises.

For the secondary educational level group, the exercises ranked first, second and third were significantly more effective than those ranked tenth, eleventh, and twelfth. At the college level the muscle action potential readings produced by the exercise ranked first was significantly higher than that produced by exercises ranked fifth through twelfth. The second ranked exercise was significantly more effective than the lowest four ranked exercises. Results for the secondary and college subjects evidenced more significant differences in the scores than did those of the elementary educational group.

The Duncan's Range Test when applied to the twelve exercises performed by all twenty-one participants yielded significant differences between the exercises ranked first and ten other exercises, or all except the second ranked exercise. The latter exercise was significantly more effective than the seven lowest ranked exercises. The third ranked exercise was significantly more effective than three other exercises; while three exercises were more effective than one other exercise statistically.

Summary

In this chapter, the results from the statistical treatment of data were presented in tabular and narrative form. The coefficient of concordance was selected for the treatment of data in order to ascertain the agreement among the different raters and among the entire group. The Chi square value was derived from the coefficient of concordance and the significance determine from a Chi square Table. The coefficients of concordance for each educational level and for the total group were significant beyond the .01 level of confidence.

An interpretation of the relative exercise rankings indicated that for the elementary and secondary school students the coefficient of concordance is sufficiently high to suggest value in the rankings. For the college age and for the total group, the coefficient of concordance was not of sufficient value to accept the ranking in as assured a manner as for the elementary and secondary educational level groups.

The highest coefficient of concordance, .92, which evidenced high agreement between the ranking obtained from the three groups was based upon the ranking of the mean action potential for each subgroup. The Chi square value for this coefficent of concordance was 30.32, which was significant beyong the .01 level of confidence. When the muscle action potential recordings for each subject were ranked and the resultant reading treated statistically, the coefficient of concordance was not as high. Between subject variation accounted for this difference.

The Duncan Range Test demonstrated difference among the twelve exercises at both the .01 and .05 level of significance in each educational level group and in the total group of twenty-one participants. The Pull Resistance exercise and the Prone Lateral Raise exercise were the exercises found to be most effective as evidenced by the largest recorded muscle action potentials.

Chapter VI will contain a summary of the material contained in Chapter I through V. The final chapter will also include a discussion of the findings, a conclusion to the study, limitations of the study, and recommendations for future investigations.

CHAPTER VI

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary of the Study

The present study was undertaken to investigate exercises for the amelioration of round shoulders recommended by authors who had published books about posture or adapted physical education since 1960. Eleven books met the criteria, and they yielded sixty-five exercises recommended for the amelioration of round shoulders. The exercises selected were evaluated by a quantitative electromyographic technique. To better understand the study an historical overview of kinesiology was presented with particular emphasis upon the insights that lead to the present knowledge of muscles, postures, and electrical activity generated by the contracting muscles.

The electronic equipment available facilitated the collection of data received from the electrical activity of the muscle during the exercises. The muscle action potential input was amplified and integrated, and a quantitative summation proportional to the muscle action potential of the ten second exercise period was provided by the digital counter.

Preliminary procedures included a pilot study to select the best exercise from each of twelve categories empirically determined to include all sixty-five selected exercises. The catagories of the exercises were based upon the common elements within the exercises that were recommended. Selection of the final twelve exercises was based upon electromyographic recordings obtained from volunteer subjects during the pilot study. The exercise in each category that consistently received the highest value by electromyography was utilized for the final study. Reliability of the procedures was established during the pilot investigation.

Twenty-one female subjects who were judged to have round shoulders, as evidenced by a scapular separation in excess of three inches as specified by Lowman,[1] executed three consecutive repetitions of each of the exercises. A ten second rest period was alloted between each repetition, and a longer, somewhat variable period was allowed between the different exercises to negate against any possible fatigue factors.

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[1]Lowman and Young, <u>op. cit.</u>, p. 108.

Seven subjects from each of three educational levels; elementary, secondary, and college, participated in the study. The various age groups were utilized to permit preliminary judgments with respect to the influence of age upon the muscle action potential during the exercises. The ranking of the exercises for each participant was based upon the mean of her muscle action potential for each of the twelve exercises. The coefficient of concordance was the statistical method utilized for the treatment of data in order to determine the agreement upon exercise rankings within the groups and among the groups. Chi Square indicated the significance of the obtained coefficient of concordance.

Duncan's Range Test was utilized to ascertain if significant differences existed between any of the twelve exercises at the .05 per cent level of significance which had been accepted for the present study. If a difference existed at that level, the data were examined further to determine if they were different at the .01 per cent level of significance.

Findings of the Study

The coefficient of concordance was significant within all groups and among all groups and for the total group beyond the .01 level of confidence. The highest coefficient of concordance was found among the elementary participants. The secondary school age subjects obtained the next highest agreement in their exercise evaluation by the electromyographic recording of muscle action potential. The college women had a relatively lower concordance; however, their agreement was still above the .01 per cent level of confidence. Even though all coefficients of concordance were significant at the .01 level, some divergence of exercise rankings was found among the three educational levels. The highest concordance among the three groups was revealed among the rankings based upon the mean action potential at each educational level rather than upon the mean performance of the total group.

Based upon the findings from treatments of the data by the Duncan's Range Test the Pull Resistance exercise and the Prone Lateral Raise of Weights exercise appear to be the best exercises of those selected for the present study. For the college level subjects, the Push Against the Wall exercise, which ranked second behind the Pull Resistance exercise, was significantly more effective than six other exercises for that age group. The ranks for the high school age group showed the Head Resistance Exercise to be in third position behind the Pull Resistance and Prone Lateral Raise of Weights exercise. The Head Resistance exercise was significantly better than three exercises for that educational level only. At the elementary educational level significant differences appeared only between the two highest and the two lowest ranked exercises.

Duncan's Range Test, when applied to the twelve exercises performed by all twenty-one participants, yielded a significant difference between the first ranked exercise, Pull Resistance, and ten other exercises, or all but the second ranked exercise, the Prone Lateral Raise of Weights. The latter exercise was significantly different than seven other exercises.

Two hypotheses were postulated at the inception of the investigation. The first hypothesis was that there was no significant difference in the muscle action potential of selected postural exercises for strengthening the trapezius muscle, as measured by quantitative electromyography. This hypothesis was rejected. The Range Test demonstrated that there was a significant difference among the two highest and the two lowest ranked exercises at each educational level and among the means of the total group of twenty-one participants.

The second hypothesis of the study was there there is no significant difference among subjects of various age levels in the muscle action potential of selected postural exercises, as measured by electromyography. This hypothesis was accepted, as the coefficient of concordance was significant beyond the .01 level of confidence among the different age groups which ranked the twelve exercises.

The ranking of the selected exercises based upon the highest coefficient of concordance (.919) is presented below:

Ranked first--Exercise number eleven: Pull Resistance

Ranked second--Exercise number twelve: Prone Lateral Raise of Weights

Ranked third--Exercise eight: Push Back Against Wall

Ranked fourth--Exercise nine: Head Resistance

Ranked fifth--Exercise number two: Wall Press

Ranked sixth--Exercise number three: Arm Circling

Ranked seventh--Exercise number four: Scapular Pinch with Arm Rotation

Ranked eighth--Exercise number ten: Trunk Extension

Ranked ninth--Exercise number five: Prone Arch from Non-support

Ranked tenth--Exercise number six: Active Chest Stretch

Ranked eleventh--Exercise number one: Wand

Ranked twelfth--Exercise number seven: Back Arch

A complete description of the above exercises may be found in Chapter IV, pages 63 to 67.

Conclusion of the Study

This investigation has demonstrated that exercises suggested for the amelioration of the postural condition known as round shoulders can effectively be ranked by quantitative electromyographic techniques. Significant differences were found to exist between the effectiveness of the suggested exercises and indicates some exercises are probably inefficient.

Limitations of the Study

During the progress of the present study the following limitations were revealed:

1. The ten second time interval that each exercise was performed may have been too long for some of the exercises. The integrated muscle action potential score is cumulative for the entire period, and some exercises had to be adapted to conform to this time interval.

2. The muscle action potential readings appeared to be influenced by the speed and range of isotonic movements. The investigator did not use a set speed of movement in the isotonic exercises as the study was kept as similar to a teaching situation as possible. The information obtained might have been more valuable if more rigid testing procedures had been imposed.

2. In the same experimental situation as described above, use the electromyograph for pre and post test evaluation of the strenghtening of the scapula adductor muscles.

3. Parallel the present study with male subjects to find if the same concordance exists and the same exercises are ranked as most effective.

4. Creative use of electromyography in designing or adapting exercises for the amelioration of a particular condition.

5. Use of the electromyographic technique to study other exercises which are recommended to ameliorate different postural deviations.

6. Design a study concerned with chinning to determine the effectiveness of the two hand positions for chinning in relation to the amelioration of round shoulders.

7. Develop a study pertaining to the possible use of electromyograph as a teaching aid in learning certain movements.

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APPENDIX I

BOOK LIST

THE ELEVEN POST 1960 PUBLICATIONS FROM WHICH THE EXERCISES FOR THE PRESENT STUDY WERE OBTAINED

Author	Book	Date
Arthur S. Daniels and Evelyn A. Davies	Adapted Physical Education	1965
H. Harrison Clarke and David H. Clarke	Developmental and Adapted Physical Education	1963
Charles LeRoy Lowman and Carl Haven Young	Postural Fitness	1960
Hollis F. Fait	Special Physical Education: Adapted, Corrective, Developmental	1966
Blanch Drury	Posture and Figure Control	1961
Hans Kraus	Therapeutic Exercise	1963
Ellen Davis Kelly	Adapted and Corrective Physical Education	1965
Gene Logan	Adaptations of Muscular Activity	1964
Grover W. Mueller and Josephine Christaldi	Remedial Physical Education	1966
Josephine L. Rathbone and Valerie V. Hunt	Corrective Physical Education	1965
Katharine F. Wells	Posture Exercise Handbook	1963

APPENDIX II

INDIVIDUAL DATA SHEET

FORM FOR COLLECTION OF DATA

Name ______________________________

Grade in school
next fall ______________________________

Age (at present) ______________________________

Weight (to nearest pound) ______________

Height (to nearest inch) ______________

Scapulae separation
(to nearest 1/4 inch) ______________

Date ______________________________
Month Day Year

Time ______________________________
Hour a.m. or p.m.

Monitor (full
scale reading) ______________
(After 30 minutes warm-up
of monitor)

Calibration (0.1 mv) ________

Offset @ 100 mv ______________

Offset @ 1.0 mv ______________

Impedance ______________

Exercise	Trial			Scores		
	1	2	3	Total	Average	Rank
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
Maximal Reading						
Minimal Reading						

APPENDIX III

MUSCLE ACTION POTENTIAL SCORES

MUSCLE ACTION POTENTIAL SCORES
FOR ELEMENTARY SUBJECTS

Exercise	Trial	Subjects						
		C.M.	C.R.	E.H.	D.C.	K.F.	B.B.	K.W.
1	1	89	216	75	55	154	60	96
	2	113	163	93	46	190	61	113
	3	134	99	114	112	162	63	105
2	1	134	171	171	240	195	100	189
	2	141	194	149	274	190	90	253
	3	146	264	203	249	199	105	193
3	1	107	251	182	186	188	109	230
	2	107	275	133	176	178	119	205
	3	93	240	164	219	173	125	205
4	1	103	268	280	245	189	85	172
	2	97	231	227	155	226	88	181
	3	78	202	135	182	225	82	171
5	1	113	94	151	56	310	73	116
	2	140	87	180	58	126	80	214
	3	157	125	148	61	102	76	98
6	1	38	92	75	68	49	82	97
	2	22	50	40	62	54	115	66
	3	21	59	61	49	34	81	59
7	1	58	87	49	73	114	64	122
	2	57	107	48	86	67	90	120
	3	55	131	50	81	98	74	70
8	1	149	515	147	249	172	112	325
	2	159	436	202	229	214	125	306
	3	136	377	185	162	182	119	306
9	1	181	367	238	301	215	135	147
	2	143	435	184	238	317	118	177
	3	141	225	96	225	244	121	160
10	1	142	297	153	124	124	182	220
	2	124	317	120	124	132	180	186
	3	137	248	128	96	133	181	209
11	1	159	756	229	358	306	249	491
	2	268	787	267	361	321	198	526
	3	203	742	309	308	289	192	554
12	1	234	811	225	265	410	261	643
	2	229	706	277	226	361	250	616
	3	242	763	227	284	367	251	635

This table may be read in the following manner: Exercise 1 (the description of which is found in Chapter IV, pages 63 to 67): The absolute average voltage reading for subject C.M. on the first trial; her muscle action potential score upon the electronic counter was 89.

MUSCLE ACTION POTENTIAL SCORES
FOR HIGH SCHOOL SUBJECTS

Exercise	Trial	Subjects C.M.	C.R.	E.H.	D.C.	K.F.	B.B.	K.W.
1	1	177	101	102	106	104	137	155
	2	150	146	116	88	137	129	171
	3	211	122	126	97	133	137	133
2	1	506	203	202	153	181	198	381
	2	677	283	211	156	163	181	366
	3	481	277	192	179	144	227	323
3	1	344	300	216	229	195	167	191
	2	298	355	200	243	171	155	166
	3	313	334	184	271	182	172	148
4	1	437	159	221	201	159	122	229
	2	396	155	124	183	143	149	222
	3	392	131	105	194	156	137	167
5	1	373	264	237	257	185	196	251
	2	312	173	272	172	156	130	288
	3	293	152	177	282	124	192	439
6	1	262	165	111	150	40	111	163
	2	284	130	90	167	61	131	173
	3	222	141	113	94	60	111	177
7	1	118	83	103	57	124	109	88
	2	115	85	109	59	91	118	75
	3	78	99	91	64	140	132	79
8	1	399	239	267	329	185	316	490
	2	359	302	277	310	169	286	320
	3	468	207	261	333	211	283	349
9	1	439	377	320	302	296	264	212
	2	470	311	341	363	260	264	196
	3	472	277	295	314	263	281	234
10	1	209	147	511	185	200	350	282
	2	171	145	526	162	202	373	400
	3	215	129	432	144	201	322	338
11	1	903	346	338	395	410	387	432
	2	862	323	383	396	284	334	384
	3	840	273	373	410	348	352	375
12	1	495	288	433	213	463	259	423
	2	276	298	346	206	470	295	406
	3	292	255	338	201	428	261	446

This table may be read in the following manner: Exercise 1 (the description of which is found in Chapter IV, pages 63 to 67): The absolute average voltage reading for subject C.M. on the first trial; her muscle action potential score upon the electronic counter was 177.

MOTION ACTION POTENTIAL SCORES
FOR COLLEGE SUBJECTS

Exercise	Trial	Subjects S.D.	D.L.	R.O.	C.T.	S.J.	J.R.	L.H.
1	1	136	117	85	54	133	310	140
	2	132	112	94	63	138	209	151
	3	99	103	121	84	122	229	250
2	1	107	213	703	206	164	165	222
	2	126	211	332	215	191	228	219
	3	133	205	299	235	148	161	227
3	1	117	228	221	114	273	228	168
	2	98	176	222	126	313	281	165
	3	107	169	218	121	290	218	189
4	1	84	215	200	111	200	288	275
	2	101	193	213	107	202	244	288
	3	138	206	234	95	232	219	295
5	1	132	190	113	128	173	190	235
	2	131	237	74	113	206	190	177
	3	131	198	87	128	148	165	283
6	1	157	330	174	98	204	138	165
	2	144	348	160	94	153	125	198
	3	103	333	143	95	181	103	212
7	1	66	72	84	114	84	75	154
	2	49	61	102	140	95	53	127
	3	50	71	88	148	84	77	143
8	1	240	236	360	301	501	392	285
	2	266	278	421	275	387	415	306
	3	298	224	305	272	404	375	337
9	1	164	177	163	200	181	326	333
	2	175	241	210	191	157	204	309
	3	219	223	226	191	131	302	276
10	1	114	198	65	199	181	211	160
	2	124	197	72	201	182	226	179
	3	129	202	65	185	194	238	167
11	1	335	344	338	307	594	456	331
	2	287	346	311	371	549	473	396
	3	332	392	317	368	573	493	437
12	1	150	187	182	314	268	416	256
	2	163	181	231	296	380	417	274
	3	180	198	226	311	325	420	301

This table may be read in the following manner: Exercise 1 (the description of which is found in Chapter IV, pages 63 to 67): The absolute average voltage reading for subject S.D. on the first trial; her muscle action potential score upon the electronic counter was 136.