MUSCLE ATROPHY OF THE DORSAL INTEROSSEI IN THE GERIATRIC HAND

A THESIS

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BY

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CHAPTER I

ORIENTATION TO THE STUDY

Introduction

In recent years, research focused on aging in humans has steadily increased, thus providing a better understanding of the aging process. Such research has indicated that a common manifestation of senescence is a decrease in muscular strength, endurance, and agility. Another correlate of this biological aging process is muscular atrophy.[1] Structurally, this wasting of muscle tissue is reflected in a decreased number of muscle fibers due to the inability of muscle to regenerate since fibrous tissue replaces the contractile elements. This physiological process has been termed senile muscle atrophy by numerous investigators.[2,3] Hands exhibiting senile muscle atrophy typically become thinner, flat and bony, and the interosseus spaces may become more prominent.

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[1]M. Rockstein, "Biology of Aging in Humans--An Overview," in The Physiology and Pathology of Human Aging, ed. M. Rockstein (New York: Academic Press, 1975), p. 3.

[2]E. Gutmann, "Age Change in the Neuromuscular System and Aspects of Rehabilitation," in Neurophysiologic Aspects of Rehabilitation Medicine, ed. A. Buerger and J. Tobis (Springfield, Ill.: Charles C. Thomas, 1974), p. 46.

[3]R. Adams, Disease of Muscle: A Study in Pathology, 3rd ed. (New York: Harper and Row, 1975), p. 459.

The palmar and dorsal interossei muscles of the hand are exceedingly important in performing fine motor tasks, such as threading a needle, writing, and buttoning clothes. Interosseous muscle participation is essential for carrying out fully the intrinsic motions of pure metacarpophalangeal (MCP) joint flexion and pure interphalangeal (IP) joint extension.[1] Electromyographic studies have shown that the interossei muscles participate in most power grips with hardly any assistance from other intrinsic hand musculature.[2,3] In particular, the dorsal interossei are solely responsible for the abduction of the MCP joint of the index, middle, and ring fingers. Few investigators, however, have studied the effects of interosseus muscle atrophy on hand functioning.[4] No studies have investigated the effects of this specific atrophy among geriatric individuals. This study was planned to address this issue.

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[1]H. Srinivasan, "Movement Patterns of the Intrinsic Minus Fingers," Annals of the Royal College of Surgeons of England 59 (January 1977): 33-38.

[2]C. Long, W. Conrad, E. Hall, and S. Furler, "Intrinsic-Extrinsic Muscle Control of the Hand in Power Grip and Precision Handling," Journal of Bone and Joint Surgery 52-A (July 1970):853-867.

[3]J. M. Landsmeer, "Power Grip and Precision Handling," Annals of the Rheumatic Diseases 21 (June 1962): 164-169.

[4]Srinivasan, Annals of Royal College of Surgeons of England.

Purpose of the Study

The purpose of the study was to determine whether hand function among elderly women was altered due to dorsal interossei muscle atrophy. This study was not concerned with the etiology of the muscular atrophy but rather was descriptive in nature. It sought to describe what significant differences may exist in the residual hand functioning between subjects with and without dorsal interossei atrophy. If significant differences existed, they could establish a need for rehabilitative treatment.

Statement of the Problem

The problem of this study was to investigate changes in range of joint motion and grip strength due to atrophy of the four dorsal interossei muscles of the aged hand. Two groups, each comprised of twenty-five women, ages sixty-five or over, living in North Carolina, were tested and evaluated during the Spring of 1979. One group consisted of geriatric women exhibiting visible bilateral muscular atrophy of the dorsal interossei muscles of their hands. The second group was comprised of subjects whose hands appeared normal and did not reveal interossei atrophy. Individuals with a history of rheumatoid arthritis, neurological deficits, or other disease processes which interfered with normal hand function were excluded from the study.

In addition, only persons capable of following instructions were tested.

Data were collected from each hand to determine significant differences in hand function which could be attributed to weak dorsal interossei musculature. Range of motion in metacarpophalangeal joint flexion was measured using a six and three-quarter inch transparent plastic goniometer. The degrees of metacarpophalangeal abduction of the index, middle, and ring fingers were measured from a hand outline and finger-palmprint.[1] Grip strength was tested with a Jamar[2] hand dynamometer for three trials. The data were subsequently compared with previously established norms for each measure.

Presentation of the Null Hypotheses

The following null hypotheses were examined in this study:

1. There is no significant difference between the two groups with respect to grip strength of the preferred hand.

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[1]Mary E. Brown, "Rheumatoid Arthritic Hands: Tactile-Visual Evaluation Approaches," American Journal of Occupational Therapy 20 (1966): 17-22.

[2]Asimow Engineering Co., 1414 S. Beverly Glenn Blvd., Los Angeles, CA.

2. There is no significant difference between the two groups with respect to grip strength of the nonpreferred hand.
3. There is no significant difference between the two groups with respect to the degrees of range of MCP joint flexion with the interphalangeal joints remain extended.
4. There is no significant difference between the groups with respect to abduction at the MCP joints of index and ring fingers.
5. There is no significant difference between groups with respect to the deviation of the middle finger of each hand.
6. There is no significant correlation between the dependent variables in the group with dorsal interossei muscle atrophy.
7. There is no significant correlation between the dependent variables in the group with normal hands.

Definitions and/or Explanations of Terms

For the purpose of clarification, the following definitions or explanations of terms have been established for use in this study:

Dorsal Interossei Atrophy.--For the purpose of this study, dorsal interossei atrophy was defined as visible bilateral depressions between the metacarpal shafts when the hand has been placed in a functional resting position.

Dorsal Interossei Muscles.--The dorsal interossei muscles are comprised of four bipennate muscles lying between the five metacarpal bones at the back of the hand. Each muscle has two muscle bellies which arise from the two adjacent metacarpal bones. They insert into a tubercle at the base of the proximal phalanges of three fingers: the first and second dorsal interossei insert into the radial side of the index and middle fingers, the third and fourth into the ulnar side of the middle and ring fingers. Each muscle also inserts into the aponeurotic expansions of extensor digitorum tendons of corresponding fingers.[1]

Dynamometer.--For the purpose of this study, a dynamometer was defined as an instrument used to measure isometric grip force in pounds and/or kilograms per square inch. The amount of pressure exerted in a forceful grip was indicated on a dial.[2]

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[1]M. K. Johnson and M. J. Cohen, The Hand Atlas (Springfield, Illinois: Charles C. Thomas Publisher, 1975), p. 28.

[2]Reynold Schmidt and J. V. Toews, "Grip Strength as Measured by the Jamar Dynamometer," Archives of Physical Medicine and Rehabilitation 51 (June 1970): 321-327.

Finger-Palmprint.--This motion-inherent evaluation approach, which has been defined by Brown,[1] records a visual image of underdeveloped palmar eminences and provides other dimensional perspectives. This technique was developed under the direction of Charles Long, M.D. within the department of physical medicine and rehabilitation at Highland View Hospital, Cleveland, Ohio. Brown's procedure incorporated the application of fingerpaint to the palmar surface of each hand. The hand was placed palm-down on a piece of paper until an imprint of the palm was produced. The finger-palmprint has been used to indicate limited palm extensibility and underdeveloped thenar and hypothenar eminences by lack of skin contact with the paper.

Goniometer.--For the purpose of this study, a goniometer has been defined as an instrument designed to measure the range of finger joint motion in five degree increments. The goniometer was comprised of a protractor with a movable and immovable bar which were aligned by contact over the dorsal surface of the bony segments with the goniometer's axis passing over the joint axis.[2]

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[1]Brown, American Journal of Occupational Therapy, p. 18.

[2]Dorthea Esch and Marvin Lepley, Evaluation of Joint Motion: Methods of Measurement and Recording (Minneapolis: University of Minnesota Press, 1976).

Hand Outline.--This technique has been defined by Brown[1] as a graphic representation of finger abduction which could be substituted for or be supplementary to goniometric measurement. This evaluative procedure was also designed to record middle finger motion in ulnar and radial deviation.

Limitations of the Study

The present study was subject to the following limitations:

(1) a group of twenty-five active female subjects aged 65 to 95 living in North Carolina who exhibited dorsal interossei muscle atrophy.

(2) a group of twenty-five active female subjects aged 65 to 95 living in North Carolina without dorsal interossei atrophy.

(3) the availability of the subjects' health and personal history data.

(4) the degree to which the subjects were representative of the populations from which they were drawn.

(5) the extent to which the groups were equated with respect to activity levels.

(6) the availability of relevant data concerning the objective assessment of dorsal interossei muscle atrophy.

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[1]Brown, American Journal of Occupational Therapy, p. 19.

(7) the permission and cooperation of subjects tested in the study and of persons legally responsible for the subjects.

CHAPTER II

RELATED LITERATURE

A survey of the literature disclosed that the present study did not duplicate any previous investigations with respect to scope and content. A review of studies which were related to intrinsic muscle function, interosseous muscle atrophy, and hand evaluation/measurement, which were of benefit to the development of this study, are presented.

Tomonaga[1] evaluated typical senile muscle atrophy using histochemical and electron microscopic examination. Subjects in this study consisted of seventy-nine elderly persons, aged sixty to ninety, without neuromuscular disease. The investigator examined one biopsy specimen of skeletal muscle from each subject. The specimens were taken from a broad distribution of trunk, arm, thigh, and calf muscles. Muscle specimens were rapidly frozen and cut in sections for enzyme histochemical study. Electron microscopy was performed under the JEM 100B microscope.

Various changes were observed in the senile muscle. Tomonaga found neuropathic changes such as group fiber

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[1]M. Tomonaga, "Histochemical and Ultrastructural Changes in Senile Human Skeletal Muscle," Journal of the American Geriatrics Society 25 (1977): 125-131.

atrophy, small dark angulated fibers and nuclear clumps especially in the 60-79 age group. Type-II (white) fiber atrophy of various grades was the most prominent finding in the muscles from patients in the 80-89 age group. Various ultrastructural changes were observed in senile muscles and corresponded to those reported for some neuromuscular diseases. In this study, the distribution of the neuropathic change appeared more frequently in the distal muscles. The type-II fiber atrophy and myopathic changes appeared more in the proximal muscles. The pattern of atrophy was similar to that found in metabolic neuropathies such as diabetic amyopathy.

The investigator concluded that there was a decrease of the muscle fiber diameter with age and more atrophy of type-II fiber with age. He suggested that various factors associated with the aging process apparently acted on the motor neurons and caused the neuropathic and myopathic changes seen in senile muscle atrophy.

Long[1] investigated the concept of intrinsic muscle motion and control of the fingers based on electromyographic observation. This researcher studied 868 hand muscles in 256 normal adult subjects. Motion of each tested finger was simultaneously recorded electrogoniometrically for the

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[1]Charles Long, "Intrinsic-Extrinsic Muscle Control of the Fingers," Journal of Bone and Joint Surgery 50-A (1968): 973-984.

MCP and proximal IP joint. Fine nickel alloy wire electrodes were inserted and remained in place in the tested muscles of the hand without causing pain throughout the performance of seven exercises.

Long found that electromyographic activity of the interossei was consistently observed only when MCP flexion or a flexed posture of this joint was combined with IP extension or an extended posture of the IP joints. The investigator contended that all motions ending in the position of MCP flexion and IP extension were accompanied by consistent interossei activity and the interossei participation seemed to fulfill a requirement for a specific flexion force at the MCP joint which was not supplied by the lumbrical or any other muscle.

From this detailed analysis of the data from all fingers, Long found variations in interosseous behavior from the typical pattern observed during combined MCP flexion and IP extension. Two variations: (1) lumbricoid and (2) pure MCP flexor were observed. The first and fourth dorsal interossei were sometimes observed as limiting their contribution to pure MCP flexion and did not participate in motion patterns requiring both MCP flexion and IP extension. Long found, however, that the majority of interossei showed the typical behavioral pattern.

Long, Conrad, Hall, and Furler[1] investigated the intrinsic muscles during electromyographic studies of power grip and precision handling. The hand muscles of 115 normal young adult subjects (ten subjects per muscle) were studied in resisted power grip and precision handling activities. Electromyograms were graded visually on a five-grade system for power grip and a three-grade system for precision handling. Power grip was measured as simple squeeze, hammer squeeze, screwdriver squeeze, disc grip, and spherical grip. Precision handling was measured as rotation and translation using a potentiometer.

The study of intrinsic participation showed that interossei and not lubricales were found to provide the MCP joint flexion forces needed in squeeze grips. The investigators concluded that the major intrinsic muscles of power grip were the interossei used as phalangeal rotators and MCP flexors. In addition, they contended that in rotation forces on the object to be rotated, the motion of the MCP joint which provided the rotation was abduction or adduction, rather than by rotation of the first phalanx. In pinch, the compression was found to be primarily provided by the extrinsic and not the intrinsic muscles.

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[1]C. Long, W. Conrad, E. Hall, and S. Furler, "Intrinsic-Extrinsic Muscle Control of the Hand in Power Grip and Precision Handling," Journal of Bone and Joint Surgery 52-A (July 1970): 853-867.

Srinivasan[1] investigated the movement patterns of "total intrinsic" minus and "interosseous minus" fingers. The movements were studied in 221 intrinsic minus fingers of fifty-one adult patients with leprosy. Of the 221 fingers examined, eighty were interosseous minus having paralysis of the interossei but not of the lumbrical muscles. The motor status of the fingers was determined by clinical examination and manual muscle testing. The two movements studied in detail were: (1) pure MCP flexion--starting from the fully open position of the finger and flexing the MCP joint only while keeping the IP joints as straight as possible; and (2) pure IP extension--starting from the fully closed position of the finger and extending only the IP joints.

The postures undergone by the finger during the test movement were determined by measuring the angles at the MCP and proximal IP joints. A graphic representation of the movement was constructed by plotting these postures as points on a graph with the positions of the MCP and proximal IP joints as the two coordinates and serially connecting the joints. Analysis of the movement pattern was made by visual appraisal of the shape of the curve and working out mean

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[1] H. Srinivasan, "Movement Patterns of the Intrinsic Minus Fingers," Annals of the Royal College of Surgeons of England 59 (1977): 33-38.

patterns of pure MCP flexion and IP extension in the two groups.

Srinivasan found that during pure MCP flexion of the interosseous minus fingers, the movement was associated with a variable amount of IP flexion during its early stages in eighty-five percent of the cases. Conclusions were drawn regarding the effect of the interosseous muscles in finger posture control. The investigator contended that interosseous participation appeared necessary for carrying out fully the intrinsic motions of pure MCP flexion and IP extension. A mild claw-finger deformity in the interosseous minus fingers was observed. Participation by the interosseous muscles appeared to be necessary to restrain the MCP joints from extending, particularly during the later stages of IP extension. In compliance with Long's investigations, this study indicated the lumbrical muscles were responsible for the finer adjustments of finger posture whereas the interossei acted as power muscles.

Ellenberg[1] presented thirty-five cases of diabetic patients exhibiting neurogenic abnormalities occurring in the upper extremities. Patients (ages 24-72) who demonstrated unequivocal, recognizable, and definitive syndromes

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[1]Max Ellenberg, "Diabetic Neuropathy of the Upper Extremities," Journal of Mount Sinai Hospital 35 (1968): 134-148.

were selected. Four features of diabetic neuropathy were emphasized: amyopathy, asthenia, sensory impairment, and radiculitis. The investigator also examined clinical features of age and duration in these patients.

The investigator found that amyopathy was most conspicuous in the first interrosseous space, although it characteristically involved all dorsal interosseous muscles bilaterally. The small muscle involvement also extended to the thenar and hypothenar eminences. Symmetrical, bilateral interosseous atrophy of hands was present in twenty-four cases. The atrophy was usually restricted to hands; but in some cases, deltoids, biceps, triceps, and shoulder girdle muscles were atrophied. In some cases, discrete fine movements of hands were poorly performed with weakness of opposition and finger extension observed.

Ellenberg found that males with neuropathy predominated in a two to one ratio in his diabetic population. The age distribution was overwhelmingly in the older population with twenty-six subjects over sixty years of age.

The investigator concluded that diabetic neuropathy in the upper extremities was not necessarily related to control or duration of the disease. Ellenberg suggested that the diagnosis of diabetes be suspected when symmetrical bilateral interosseous atrophy was exhibited without neurological etiology evident. The study indicated that amyopathy of the small hand muscles, most marked in first interosseous space, predominated in males and in the older diabetic population.

Bienenstock, Davidson, and Forschner[1] investigated the atrophy of the first dorsal interosseus muscle to ascertain it as a clinical sign of impaired glucose metabolism. Thirty-two bedridden or semi-ambulatory patients exhibited clinically observable first dorsal interosseous muscle atrophy. Of these patients, eighteen subjects whose mean age was 77.8 years had no previous history of diabetes mellitus. The hands were examined by two independent examiners. Patients with arthritis or neuromuscular disease were excluded from the study. A group of patients which was without atrophy served as controls and was matched for age and sex with patients having atrophy. Three-hour oral glucose tolerance levels were found for all three groups.

In this study, significant differences were noted in the mean glucose tolerance test values in patients with and without interosseous atrophy who had no previous history of diabetes mellitus. The findings indicated that a large proportion of patients with first dorsal interosseous muscle atrophy had overt diabetes mellitus. Decreased

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[1]H. Bienenstock, S. Davidson, and T. Forschner, "First Dorsal Interosseous Muscle Atrophy," New York State Journal of Medicine 71 (April 1971): 851-854.

glucose tolerance was also noted in a significant number of subjects with first dorsal interosseous muscle atrophy who had no previous history of diabetes mellitus. These findings agreed with Ellenberg's conclusion that the specific interosseous atrophy was a useful clinical sign for the detection of patients with impaired glucose tolerance.

Jung et al.[1] studied the diabetic hand syndrome which he found associated with dysaesthesia of the hand, wasting of the intrinsic hand muscles, atrophy of palmar tissues, and delays in nerve conduction. Subjects in this study consisted of fifty-one adults having a mean age of 43.6 years. Each subject had been previously diagnosed with diabetes mellitus based on persistent fasting and undue postglucose hyperglycemia.

The subjects' hands were examined for atrophy of interossei, thenar, and hypothenar muscles; atrophy of palmar tissues; and for flexion contractures of the fingers at the phalangeal joints. Note was made of any thickening or shortening of palmar tendons and of sharply angulated contractures of the MCP joints of the classical Dupuytren's type. Touch and two point discrimination were tested at the radial and ulnar condyles using a biothesiometer that

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[1]Y. Jung, T. Hohmann, J. Gerneth, J. Novak, R. Wasserman, B. D'Andrea, B. Newton, and T. Danowski, "Diabetic Hand Syndrome," Metabolism 20 (1971): 1008-15.

measured vibration sense threshold. Motor nerve conduction velocity was measured in one or both forearms.

The diabetic subjects were placed into three groups. Group one was comprised of subjects showing no signs of intrinsic muscle atrophy or flexion contractures of fingers. The second group exhibited only intrinsic muscle atrophy, while the third group manifested both muscle atrophy and finger contractures. The investigators compared the three groups on various measures to determine whether statistically significant differences existed.

The investigators concluded that when digital flexion deformity was present, the atrophy of the intrinsic hand muscles was more severe. Jung et al. indicated that the higher frequency of delayed median nerve transmission from the wrist to the fingers in the group with flexion contractures could be secondary to the contractures. Stiffness of the tissues interferes with nerve conduction and further aggravates the neuropathy and intrinsic atrophy. Since such symptoms may be indicative of carpal tunnel syndrome, the data indicated that these symptoms were partially attributable to intrinsic median nerve neuropathy or myoneural dysfunction.

The performance of the elderly in a variety of hand skills was studied by Bell[1] to determine the presence or

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[1]Esther Bell, "A Measurement of Hand Skill Decline in Aging" (M.A. Thesis, Texas Woman's University, 1971).

absence of a decline in hand functioning with aging. The investigation sought to provide further information concerning the normal characteristics of hand skill in the geriatric population. Forty-eight subjects were grouped into three categories according to age which ranged from forty-five to seventy-five years. All subjects had no known neurological deficits and were independent in self-care.

Bell devised the Physical Capabilities Evaluation to test all the subjects in the study. This evaluation included five tests of hand skill for each hand. Each test measured a different type of hand skill, such as fingertip pinch, tripod prehension, and fingertip prehension. The mean for each subtest with each hand in each age group was computed to compare central tendencies. Mean scores of the dominant hand were selected for comparison of the five tests. The right hand scores were subsequently compared with the left hand scores for each test. The data were analyzed through use of analysis of variance and _t_-tests.

Results of Bell's study indicated that a significant decline of hand skills occurred when comparing the group of 45-54 year olds with the group over sixty-five years. A more rapid rate of decline in one hand for persons between fifty-five and sixty-four years of age was indicated in the investigation. The difference between hands appeared to be less after sixty-four years of age.

Dworecka et al.[1] described pictorial data to be used in hand evaluations. The investigators chose standard hand outlines, hand-prints, and hand-spread outlines to graphically represent the hand. Procedures in collecting data followed the recommendation of Brown.[2] Subsequent range of motion tests were depicted in colored ink for visual clarity. Each pictorial record was supplemented by goniometric readings at a given joint. Re-evaluation tests of the hand-spread outlines were superimposed on the original outline to indicate change. Illustrative cases of mild, moderate, and severe hand deformity were presented to demonstrate the clinical practicality of pictorial data.

The hand-prints supplied visual information concerning the volar aspect of the hand. The normal hand was described as showing all phalanges touching the paper in good alignment without undue thenar and hypothenar outline flatness. The hand-spread outline provided visual data pertaining to the medio-lateral alignment of hands and wrists to MCP abduction.

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[1] F. Dworecka, Y. Challenor, P. Spector, L. Kaplan, and L. Wisham, "A Practical Approach to the Evaluation of Rheumatoid Hand Deformity," American Journal of Orthopedic Surgery 32 (April 1968): 96-101.

[2] M. E. Brown, "Rheumatoid Arthritic Hands: Tactile-Visual Evaluation Approaches," American Journal of Occupational Therapy 20 (1966): 17-22.

The investigators concluded that prints and outlines of the hand were practical methods of documenting hand mobility, strength, and deformity. Photography was considered more difficult and could produce misleading results secondary to its problems of exposure, lighting, and shadow formation. It was recognized, however, that the described methods of hand evaluation had limitations consisting primarily of the bi-dimensional measurements which must be integrated into a tri-dimensional concept.

Garrett[1] summarized recent studies concerning the anthropometric and biomechanical evaluation of the hand. This included conventional hand anthropometry of 211 Air Force female personnel whose mean age was 20.4 years. Garrett measured fifty-six dimensions of the straight, flat, fully extended hand using a measuring board, a steel metric tape, and sliding calipers. The wrist crease formed at the bases of the thenar and hypothenar eminences was used as the proximal baseline for measuring digit height and hand length dimensions in inches.

Garrett presented descriptive statistics of thirty-four dimensions of male and female hands. Nomographs for

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[1]John Garrett, "The Adult Human Hand: Some Anthropometric and Biomechanical Considerations," <u>Human Factors</u> 13 (April 1971): 117-131.

certain of the more important hand dimensions were included. A straight line drawn through the known values of hand length and hand breadth at the metacarpals also passed through the average values of other dimensions (e.g. digit length).

Garrett concluded that specific anatomical landmarks for hand length measurements varied among anthropometric studies. It was considered imperative that data from various surveys not be used for hand comparison unless identical landmarks were used.

Barnett and Cobbold[1] studied the influence of age upon the mobility of finger joints. The frictional forces were examined in the finger joints of 111 healthy adults aged 17-90 years. Any person exhibiting Heberden's nodes, swelling, deformity, or a history of pain or trauma were excluded from the investigation. The coefficient of friction was measured using an apparatus consisting of a swinging pendulum attached to the end of the middle finger. The rate of decay of amplitude of the freely swinging pendulum allowed calculation of the forces restricting joint mobility. Each finger tested carried approximately 430 grams to allow accurate comparison between subjects.

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[1] C. H. Barnett, A. F. Cobbold, "Effects of Age Upon the Mobility of Human Finger Joints," Annals of the Rheumatic Diseases 27 (1968): 175-177.

The investigator found no significant difference between the joint mobilities of males and females and therefore considered both sexes together in the analysis. The mean coefficients of friction were found to increase with age, but there was a wide scatter about the mean. The mean coefficient in the elderly differed significantly from that found in university students.

Barnett and Cobbold concluded that the mean coefficient of friction within the distal IP joint of the middle finger was significantly higher in the elderly. The study indicated that the reduced joint mobility that was observed depended on age change in the synovial fluid, articular cartilage, or joint ligaments since the testing apparatus eliminated the damping effect of muscles and tendons.

Loebl[1] presented two methods to assess the mobility of MCP joints in the hand. In 108 normal men and 120 normal women aged 20-80 years the angle between the third and fourth fingers was measured in each hand. MCP abduction was measured with the MCP joints flexed to ninety degrees with standardized abducting forces applied to the fingers. Forty-seven subjects were also investigated by axial traction.

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[1]W. Y. Loebl, "The Assessment of Mobility of Metacarpophalangeal Joints," Rheumatology and Physical Medicine 11 (Nobember 1972): 365-379.

In the abduction method of assessment, a portable instrument was designed to test the lateral stability of the MCP joints in flexion. Equal moments of force were distributed to the adjacent borders of the two fingers via pulleys. The angle between the two abducted fingers were calculated from two protractor readings taken within 5-7 seconds of each application of force up to 10 kg. cm. The axial traction method produced an increase in the MCP joint gap which was measured from anterior-posterior macroradiographs. Traction at 1 kg. increments was used up to 4 kgs.

Various results were presented by the investigator. No significant statistical difference was found in the abduction test between the results of any two age groups. Females were found by both methods to be more mobile than males in MCP abduction. In axial traction, the mean increase in joint gap of females was nearly twice that of males. This difference between the sexes was significant for every age decade. Dominant hands were less mobile than non-dominant hands in the abduction method.

The investigator concluded that abduction of the flexed fingers varied between individuals but did not change appreciably with age. Loebl suggested that hand dominance affected MCP mobility through the difference and frequency in use. The study indicated that both assessment methods provided objective repeatable measurements of the mobility of MCP joints.

In another study of MCP joint mobility, Iregbulem, Nicolle, and Calnan[1] measured the angles of digital deviation in the normal hand and assessed the effect of age on the range of deviation. Subjects consisted of forty healthy adults with normal hands whose ages ranged from 18-70 years. The "dual action" goniometer was used to measure digital deviation at the MCP joint.

The investigators stabilized the subjects' pronated forearm and hand on the "platform" with fingers pointed towards the observer. The MCP joints were allowed to flex (0-5°) for comfort and the midpoints of the dorsal proximal IP and MCP joints were marked with a pen. To prevent digital drift and MCP drift, rods were inserted in the platform alongside the second and third distal IPs and MCPs. The mean of three readings for each digit in each of four positions (neutral, active radial deviation, active and passive ulnar deviation) was taken. Means and standard deviations were recorded for all forty subjects and a t-test conducted.

Among the many findings, the investigators found a significant difference between the values of active and

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[1]L. M. Iregbulem, F. V. Nicolle, and J. S. Calnan, "Measurement of Digital Deviations: A Simple Device," _The Hand_ 6 (1974): 166-171.

passive radial deviation in individual digits in the male and female hands. No significant difference between the sexes was found, however, for active and passive ulnar deviation values. The range of digital deviations in the right and left hands did not vary significantly in the same individual.

The investigators concluded that a relationship between collateral ligament length and the angle of digital deviation existed with a greater range of ulnar deviation observed in the study. They suggested that female ulnar collaterals may be longer than their male counterparts due to the finding that female range of active radial deviation was significantly higher than males. Finally, the study indicated that age had no influence on digital deviations which concurred with Loebl's findings.

Matheson, Sinclair, and Skene[1] studied the range of active deviation at the MCP joint and of the forces produced by these movements. In the first part of this investigation, eighteen male and nineteen female medical students participated as subjects. MCP deviations on radiographs were measured using a protractor and two thin perspex strips. The strips were placed on the long axis of the appropriate

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[1]A. B. Matheson, D. C. Sinclair, and W. G. Skene, "The Range and Power of Ulnar and Radial Deviation of the Fingers," Journal of Anatomy 107 (1970): 439-458.

bone. Each angle produced by the IP joint with its corresponding MCP joint was measured twice on different occasions, by the same investigator, and the mean of the resulting measurements was determined. The investigator presented six experiments: maximal divergence and convergence, mass deviation, individual MCP deviation, effect of position of other fingers, and maximal deviations.

Among the many findings, only those concerning range of joint motion were presented in this review. The investigator found from maximal convergence and divergence that the fingers moved to and from the center line of the middle finger, which moved minimally. The range of movement of each finger differed significantly from the others with the fifth digit being the most mobile. When the effect of other fingers was investigated, the results indicated that the maximal radial deviation of the index finger and the maximal ulnar deviation of the little finger were not affected by the position adopted by the other fingers. When measuring maximal deviations of fingers with no attempt made to keep fingers together, several findings resulted. First, the resulting standard deviations reflected considerable individual variation in index finger movement. Secondly, the range of movement of the index finger was significantly greater than that of the ring finger but not as great as the little finger range of movement. Finally, when comparing mass deviation, the range of movement of the second and fifth digits was significantly greater in the females than in the males.

The investigators concluded from their experiment on the range of motion of lateral deviation of the fingers that a method of quantitative and reproducible assessment produced by such movements could be used clinically. Matheson et al. suggested that a considerable restriction of the movement of every finger resulted if the fingers are kept together during ulnar or radial deviation. The female subjects were less hampered by this restriction than the male subjects, but were similar in free maximal deviation in either direction. The investigators observed that "learning" of radial and ulnar deviation motion occurred with practice, being maximal in the ring finger and minimal in the index finger. When the fingers were strongly deviated, metacarpal rotation occurred particularly in the fifth and second MCP. This movement was associated with an attempt at cupping the hand and flexing the MCP joints. No rotation of the metacarpals was observed, however, during maximal convergence or while spreading the fingers as far as possible.

Chapter III presents the methods and procedures which were used in the present study.

CHAPTER III

METHODS AND PROCEDURES

The primary purpose of this study was to determine the presence of altered hand function manifested by elderly women exhibiting visible dorsal interossei muscle atrophy. Specifically, the investigator analyzed range of MCP joint motion and grip strength to determine the relationships between hand function and dorsal interosseous spaces.

This chapter contains the methods and procedures used to attain the purpose of this study. They are included in the following center headings: Preliminary Procedures, Selection of Subjects, Selection of Instruments, Data Collection Procedures, Organization and Treatment of Data, and Preparation of the Final Report.

Preliminary Procedures

An outline of the proposed study was prepared for approval by the members of the thesis committee. Following suggestions of the thesis committee, a revised outline was completed. Later a prospectus was submitted to the Office of the Provost of Graduate School at the Texas Woman's University, Denton, Texas, and permission from the TWU Human Research Committee was obtained.

The study was subsequently approved by the Committee on the Protection of Rights of Human Subjects at the University of North Carolina School of Medicine in Chapel Hill. This permitted the investigator to select subjects associated with the North Carolina Memorial Hospital such as hospital volunteers, employees, or patients. Finally, permission was secured from the Joint Orange-Chatam Community Action Program to select subjects participating in their community day centers. All permission letters appear in the appendix (see Appendix A).

Selection of Subjects

The subjects who participated in the investigation were fifty active women over sixty-five years of age living in Chapel Hill, North Carolina during the Spring of 1979. All subjects were alert and capable of following verbal instructions. Invididuals with moderate to severe arthritis, central nervous system damage, peripheral neuropathies or any other disease process which would interfere with hand function were excluded from the study. Each subject was assigned to one of two groups. One group consisted of twenty-five geriatric women exhibiting dorsal interossei atrophy of both hands. Hands which demonstrated depressions in the narrow spaces between the metacarpal bones when positioned in a functional resting position were defined as having dorsal interossei atrophy. The second group consisted of twenty-five subjects exhibiting normal geriatric hands without the presence of visible muscle atrophy on the dorsum of the hand. Subjects were assigned to a group only after hand examination and muscle palpation were performed.

Subjects were initially considered for inclusion in the study provided they were healthy, active, and over sixty-five years of age. The investigator relied on volunteers and referrals to secure subjects. Members of the hospital auxillary, women's clubs, and other volunteer organizations were contacted and questioned concerning their willingness to participate in the study. Names of potential subjects were obtained mainly from women who had previously participated in the study. After the twenty-five normal subjects had been tested, the investigater became more selective in finding women who would meet the criteria for the atrophy group.

Geriatric women living in a restricted environment such as a rest home or nursing home were not included in the study. Hand atrophy exhibited in women with a decreased activity level could be secondary to disuse atrophy rather than senile muscle atrophy or diabetic amyopathy. Independent homemakers who routinely performed manual leisure activities such as handicrafts and gardening were considered desirable subjects.

Before collecting any data, each potential subject was required to read and sign a research consent form which complied with the Human Research Committee's requirements (see Appendix B). When subjects were drawn from a specific facility or community program, written approval or verbal permission was obtained from the appropriate authorities.

Selection of Instruments

Selection of instruments was based on the following criteria: reliability, validity, objectivity, and availability of norms. The instruments employed in the study were a hand dynamometer and two goniometers.

The Jamar Dynamometer,[1] used to measure grip strength, was selected for its adjustable handle, reliability, availability of norms, and its ease of calibration. Betchol[2] recommended a dynamometer with adjustable handle spacings which was found to record maximum grip of various hand sizes most effectively. The instrument used in this study featured an adjustable handle which accommodated five hand size positions. The Jamar dynamometer has been used in many grip strength studies and has provided reliable, accurate and

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[1] Asimow Engineering Company, Los Angeles, Ca.

[2] Charles Bechtol, "The Use of a Dynamometer with Adjustable Handle Spacings," The Journal of Bone and Joint Surgery 36-A (1954): 820-824.

reproducible readings.[1] Norms for the Jamar dynamometer have been established by Kellor et al.[2] according to sex and age up to eighty-four years. Throughout the study, the dynamometer calibration was checked for validity by utilizing a simple means of weight loading to assure that the dial reading corresponded accurately with the force applied.

The instrument selected for measurement of metacarpophalangeal (MCP) flexion was a 180 degree clear plastic goniometer. The instrument used in this study was manufactured by Fred Sammons, Inc.[3] It was selected for its reliability and its ease of operation and adaptability. Hamilton and Lachenbruch[4] concluded from their research that the different types of available goniometers were equally reliable for determining finger joint angles. Boone et al.[5] presented the average of intratester reliability ($\underline{r}$ = .89) for upper extremity goniometer measurement. They contended

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[1]Schmidt and Toews, Archives of Physical Medicine and Rehabilitation, p. 326.

[2]Marjorie Kellor et al., Technical Manual of Hand and Dexterity Tests (Minneapolis: Sister Kenny Institute, 1971).

[3]Be OK Plastic Goniometer. Fred Sammons, Inc., Be OK Self-Help Aids, Box 32, Brookfield, Illinois.

[4]George Hamilton and Peter Lachenbruch, "Reliability of Goniometers in Assessing Finger Joint Angle," Physical Therapy 49 (1969): 465-469.

[5]D. C. Boone et al., "Reliability of Goniometric Measurements," Physical Therapy 58 (1978): 1355-1360.

that variation among the goniometric measurements taken by one tester was less than that of the measurements taken by several testers.

In the present study, Pearson product-moment correlations were computed for the three trials of goniometric measurements of the flexed MCP joint of the index finger to determine the tester's reliability in assessment. A computer program was executed on a Data General Corporation Eclipse C350 computer via a display terminal. The three trials of measurement were divided into sets of two variables which was the required format for establishing a correlation. The relationship between the second and third trials was greater ($\underline{r}$ = .96) than the others ($\underline{r}$ = .87, $\underline{r}$ = .90) perhaps due to better subject understanding of the instructions. The investigator's average reliability ($\underline{r}$ = .91) for measuring MCP joint flexion using goniometry was considered satisfactory.

The 180 degree goniometer was selected because of its ease of placement over the dorsum of the small finger joints. In addition, the six and three-quarter inch goniometer was cut to produce a three inch "finger goniometer" to increase the accuracy of measuring the MCP joint angle. To measure isolated MCP flexion, volar aluminum finger splints were designed to prevent interphalangeal (IP) flexion during maximal MCP joint flexion. The splints were secured to each finger with one velcro strap over the proximal IP joints to insure pure MCP flexion. The three inch goniometer and the volar splints did not interfere with each other's function. Normal MCP range of motion was defined as ninety degrees of flexion.

Various methods and instruments were selected for measurement of MCP abduction. Among the criteria for instrument selection were reliability, objectivity, and the availability of norms. This study employed three separate means of measuring MCP abduction. Three different procedures were used since previous research had not established any single procedure as superior. The measurement procedures used, however, were based on the recommendations and preferences of previous researchers. Peskett[1] suggested that finger/hand span be measured in centimeters between the centers of the distal IP joints when assessing joint function. In finding fingertip spread, Garrett[2] measured the distance between the most lateral aspects of the finger pads in inches. Many sources cite an alternate method of measuring finger abduction by drawing an outline of the hand

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[1]E. B. Peskett, "Hand Assessment--A Realistic Reappraisal," The Hand 9 (1977): 135.

[2]John Garrett, "The Adult Human Hand: Some Anthropometric and Biomechanical Considerations," Human Factors 13 (April 1971): 117-131.

lying flat on a table. Brown[1] supplemented this technique by the additional measurement of middle finger excursion and by incorporating a hand palmprint.

In this investigation, all of the aforementioned measurement procedures were utilized. All appeared quite objective and without ambiguity. Normal or average measures were available only for Garrett's procedures. A clear plastic 180 degree goniometer and a six inch transparent metric ruler were selected to measure the hand outline.

Data Collection Procedures

The majority of subjects were tested in their own homes in a quiet room with good lighting. Typically, a coffee table or kitchen table was available to provide the surface necessary to collect palmprints and hand outlines. The test equipment and data sheets were gathered and placed in a small briefcase for easy mobility. A typical testing session required between thirty and forty-five minutes to complete. No follow-up visits were necessary. All subjects read and signed a research consent form prior to the implementation of any testing procedures.

Once seated and relaxed, each subject was questioned concerning age, hand preference, former occupation, medical

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[1]M. E. Brown, "Rheumatoid Arthritic Hands: Tactile-Visual Evaluation Approaches," American Journal of Occupational Therapy 20 (1966): 17-22.

status, and daily activity level. After personal data were collected through a brief interview, the subjects' hands were visually inspected for dorsal interossei atrophy. Each hand was positioned in a volar polyform resting hand splint[1] which allowed thirty degrees of wrist dorsiflexion with a normal transverse palmar arch; the IP and MCP joints were placed in slight flexion and the thumb in opposition. Once in the splint, the hand was inspected for depressions in the narrow spaces between the metacarpals.

Following visual inspection for atrophy, manual muscle testing of the interossei was performed. The muscular portion of the first dorsal interosseous was palpated in the space between the metacarpal bones of the thumb and the index finger as manual resistance was applied in abduction. The second, third, and fourth dorsal interossei muscles were palpated at their insertions at the base of the proximal phalanges when finger abduction was resisted.[2] A one inch wide elastic loop served as the resistance to finger abduction during palpation.

Following muscle testing, the subjects were administered the test for grip strength using a Jamar dynamometer.

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[1]Polyform Orthotic Splint Material. Roylan Medical Products, P. O. Box 555, Menomonee Falls, Wisconsin.

[2]Signe Brunnstrom, Clinical Kinesiology, 3rd ed. (Philadelphia: F. A. Davis, 1972), p. 115.

Subjects were instructed to squeeze the dynamometer with the handle spacing at the 1.5 notch since this adjustment has been found to permit the maximum grip strength for females.[1] Each subject was seated and was not permitted to bring the instrument or arm in contact with the body while squeezing the dynamometer. Initially, subjects squeezed the instrument with the preferred hand and then alternated hands. Each subject was given three trials with each hand, the best score being used as the raw score for each hand. A minimum of five minutes was allowed between each trial to eliminate muscle fatigue. Dynamometer readings were carefully watched to detect malingering. The Instrument was checked for calibration between subjects.

After the first trial with the dynamometer, the subject was instructed to maximally flex her MCP joints while keeping the IP joints in extension. The distal and proximal IP joints were stabilized with volar aluminum finger splints and secured with an adjustable velcro strap. The seated subject rested her elbow and forearm on a table with the forearm in midposition and the wrist in slight hyperextension. The axis of a 180 degree goniometer was placed directly above the dorsal aspect of each MCP joint axis

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[1]Bechtol, The Journal of Bone and Joint Surgery, p. 823.

after active flexion had been performed to insure a greater degree of accuracy.[1] The stationary goniometer arm was aligned on the dorsum of the finger along the midline of the metacarpal and the movable arm on the dorsal surface along the midline of the proximal phalanx. The index, middle, and ring fingers were each measured three times in an attempt to establish the tester's reliability of assessing MCP joint angle. The mean angle of three trials for each MCP joint was used as the raw score. An assessment of passive range of motion was also implemented to rule out structural limitations in the MCP joint range.

To produce a hand outline, the seated subject was instructed to pronate the forearm and place her palm flat on the paper while maximally abducting her fingers. This was necessary to avoid flexing the MCP joints or cupping the hand which would allow metacarpal rotation. Also the heel of the palm was kept firmly on the table to avoid compensatory motion of the wrist flexors and extension digitorum muscles. The hand was carefully watched for MCP joint hyperextension and "rolling" of the palm onto the paper. These precautions were also applied to the palmprint procedure.

Once the subject properly positioned her hand on the paper, an outline was drawn of the hand with a pencil held

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[1]Sue Hurt, "Joint Measurement," American Journal of Occupational Therapy 3 (1947): 209-214.

perpendicular to the paper. The distal IP joints and the wrist crease were marked on the hand outline. While the second and fourth digits were manually stabilized in abduction, the subject was instructed to move the third digit toward the index finger as far as possible. The finger was re-outlined in radial deviation. The subject was then instructed to move the same finger in ulnar deviation and the middle finger was re-outlined again. This procedure was repeated with the subject's other hand. In addition to MCP abduction, this finger-spreading outline furnished evidence of middle finger excursion.

The final subtest administered was the finger-palmprint. In this study, an electrostatic method was substituted for the fingerpaint method. The subject was instructed to smooth oil-based hand lotion liberally over the palmar surface of each hand to enhance the clarity of the palmprint. The subject opened her hand fully, spread the fingers widely and firmly placed the hand palm-down on an 8 3/4 by 12 inch electrostatic multilith pressure-sensitive paper.[1] The subject kept her hand flat on the table as the investigator outlined the hand with a pen. Once the outline was completed, the subject raised her hand

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[1]Electrostatic Multilith Masters series 8-2004. Copiers Duplicator Division, AM Corporation, 1200 Babbitt Road, Cleveland, Ohio.

straight upward off the paper. Subsequently, the investigator carefully marked the areas of palmar contact with the paper. This procedure was repeated with the subject's other hand.

If available, the electrostatic paper could be run through a 2875 offset printing process which essentially drops black toner on the multilith paper to produce a printed reproduction of the palmprint. Unfortunately this process was not readily available during the study. The electrostatic method was preferred to fingerpaint because of its convenience and neatness.

From the hand outline, additional data were collected. Hand height, as an indication of relative hand size, was measured by a line parallel to the long axis of the hand. The distance from the wrist crease baseline to the longest finger tip was calculated in inches (see Figure 1). Digit length was measured using the distance along the axis of the third digit from the midpoint of the tip of the same digit to the average level of hand crotch. The various assessment methods of MCP abduction were also derived from the hand outline. Anthropometric methods were utilized in finding the finger tip spread of digits two and four and of middle finger excursion. Lines perpendicular to the wrist crease were drawn and touched the ulnar or

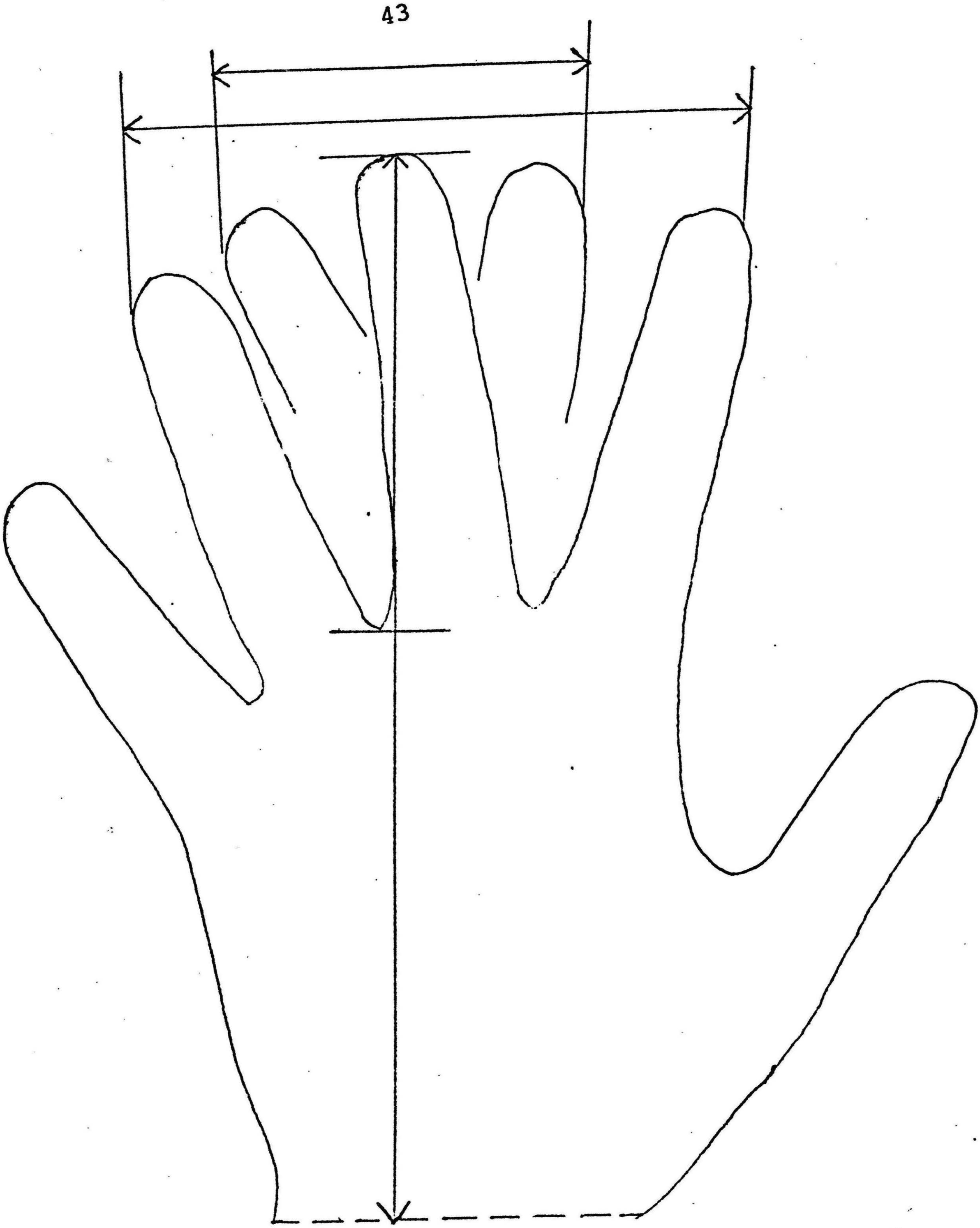

Fig. 1. Anthropometric Measurement of Fingertip Spread, Hand Height, and Digit Length

radial side of the distal phalanges during maximal finger abduction. The distance from the finger edge furthest from the hand axis and another finger was measured in inches. Another method of assessing MCP abduction incorporated measuring the distance between the centers of the distal IP joints in centimeters. The span between the second and fourth digits and in middle finger excursion were calculated. Finally, the angle of radial and ulnar deviation of the middle finger was determined by a plastic 180 degree goniometer. Lines were drawn from the center of the distal IP joints to the midpoint at the base of the middle finger (see Figure 2). The goniometer arms were placed on the lines to measure the angles of ulnar, radial, and total deviation from the middle finger longitudinal axis.

Data concerning palmar atrophy and MCP extension were collected from the finger-palmprints. A normal hand conveyed full rounded thenar eminence contact from the wrist crease along the radial border of the palm and extending distally to the level of the web of the thumb, and with skin contact by all finger phalanges such that all segments have touched the paper in almost a continuous pattern (see Figure 3). When minimal contact or abnormal contours occurred in the palmar areas, it was judged indicative of palmar atrophy. When the MCP regions of the second, third

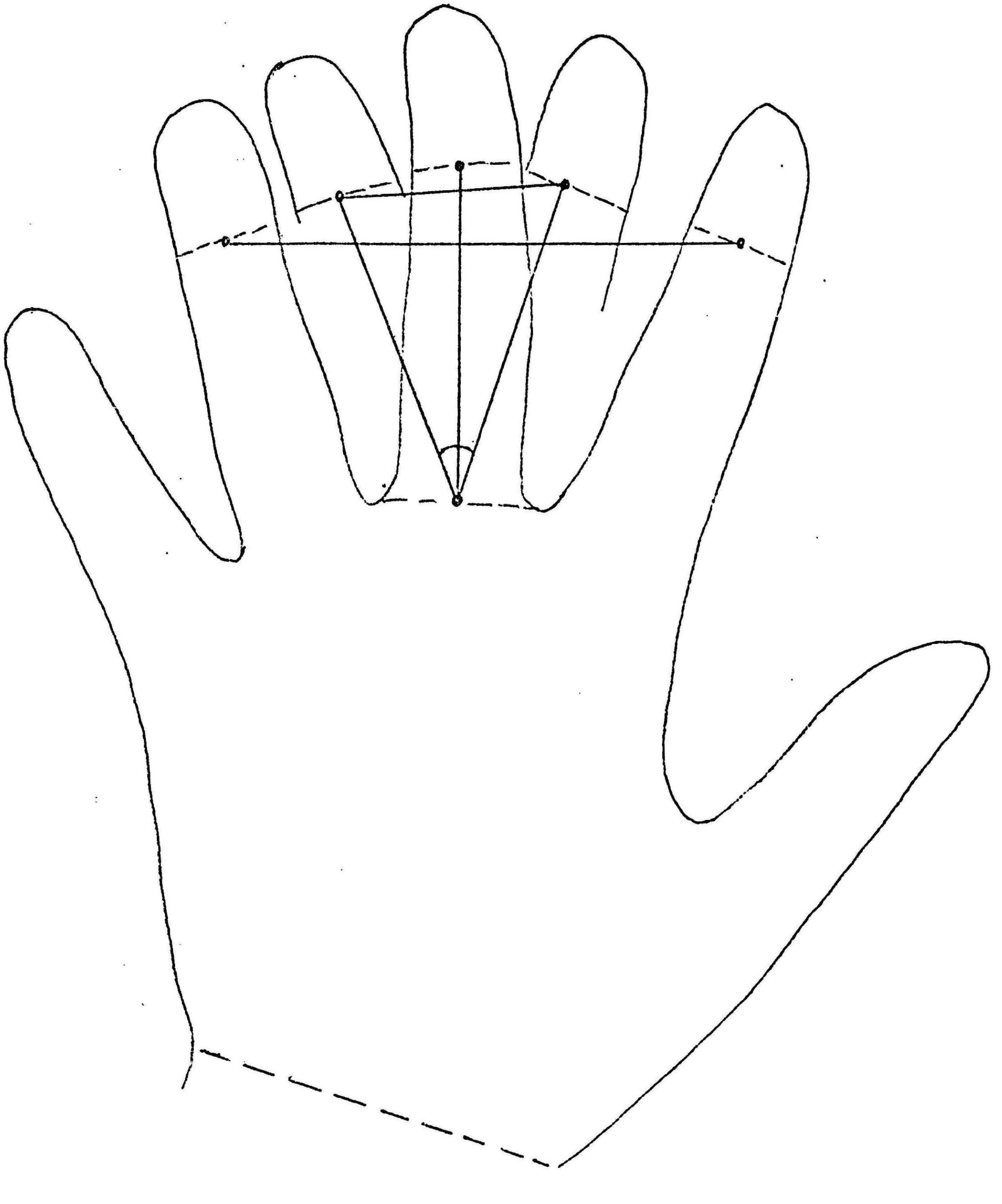

Fig. 2. Measurement of the Angles of Digital Deviation and the Distance Between the Distal IP Joints.

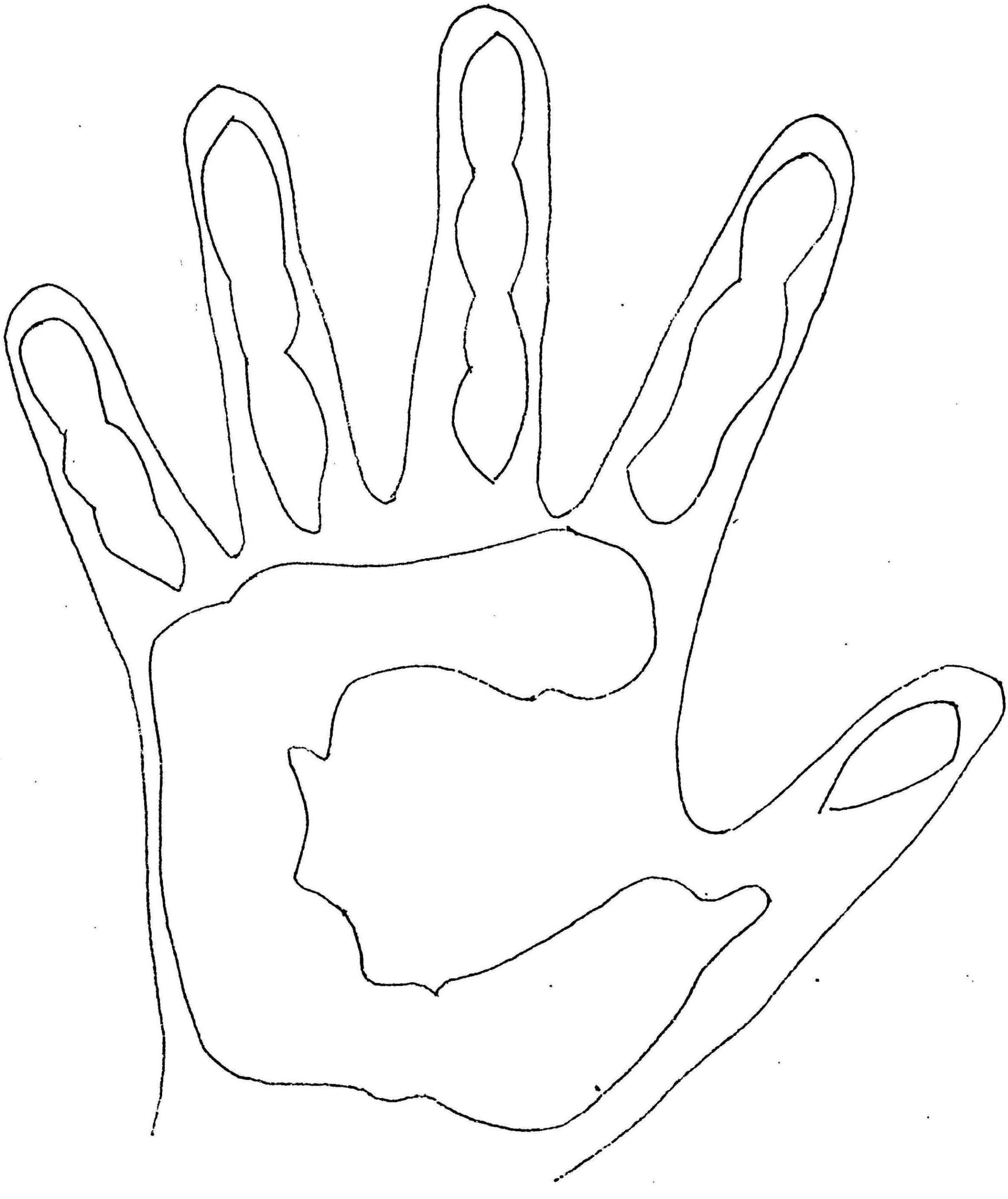

Fig. 3. Illustration of a Normal Palmprint

and fourth digits did not contact the paper, it was concluded that limitations of proximal IP extension was present.

Organization and Treatment of the Data

Data were collected on each of the dependent variables: age, grip strength, pure MCP flexion, digit height, MCP abduction, presence of palmar atrophy, and MCP extension. The best of three dynamometer trials for each hand was used as the raw score for grip strength. The mean of three goniometer measurements for each MCP joint was the raw score for pure MCP flexion. Digit height and MCP abduction were determined from the hand outline. The presence of thenar atrophy and limited degrees of MCP extensibility were assessed from the finger-palmprint. The data were organized in appropriate tables and illustrations for presentation in the appendix.

Each subject's raw data were coded on computer cards for subsequent computer analysis. For each of the two groups, the range, means, standard deviations, standard errors of the mean, and Pearson Product Moment Correlations of all the variables were found employing the SPSS statistical package.[1] Statistical differences between the two

[1] N. Nie et al., Statistical Package for the Social Sciences, 2nd ed. (New York: McGraw-Hill Book Company, 1975).

groups were subsequently computed using t-tests to determine if significant differences existed between each of the dependent variables.

Preparation of the Final Written Report

The data were organized and presented in appropriate tables and illustrations. The data were then summarized and conclusions were drawn. A final written report of the study also included implications of the findings and recommendations for future research. A classified bibliography and appendices were added in order to compare the written report.

In Chapter IV of this thesis, the investigator will present the findings of the study.

CHAPTER IV

PRESENTATION OF THE FINDINGS

The purpose of this study was to determine whether hand function among elderly women was altered due to dorsal interosseous muscle atrophy. Specifically, differences in grip strength, pure metacarpophalangeal flexion, and MCP abduction were investigated between the hands of subjects in the normal group and in the atrophy group. In addition, hand outlines and finger-palmprints were utilized to gather information regarding the presence of palmar atrophy and limited MCP extension. The following null hypotheses were examined:

1. There is no significant difference between the two groups with respect to grip strength of the preferred hand.
2. There is no significant difference between the two groups with respect to grip strength of the nonpreferred hand.
3. There is no significant difference between the two groups with respect to the degrees of range of MCP joint flexion with the interphalangeal joints remain extended.

4. There is no significant difference between the groups with respect to abduction at the MCP joints of index and ring fingers.
5. There is no significant difference between groups with respect to the deviation of the middle finger of each hand.
6. There is no significant correlation between the dependent variables in the group with dorsal interossei muscle atrophy.
7. There is no significant correlation between the dependent variables in the group with normal hands.

The data obtained from the interview and the administration of various hand subtests were subjected to statistical treatment and the results were presented in table form and summarized in this chapter. The findings of this study appear under the following headings: Description of the Subjects, Comparison of the Groups, Interrelationships of the Variables, and Summary of the Findings.

Description of the Subjects

The subjects for the investigation were fifty active homemakers, aged 65 to 86 years, living in Chapel Hill, North Carolina during the Spring of 1979. All subjects reported right hand preferences. Each subject was assigned to one of two groups following pre-established criteria determining the presence or absence of dorsal interossei atrophy. The mean age of the subjects exhibiting the muscle atrophy was 75.08 years. The mean age of the normal subjects was 73.28 years. The difference between the mean ages of the groups was not statistically significant (see Table 1). All of the subjects were alert and highly capable of following verbal instructions. It was observed that seventeen subjects in each group reported being retired from such professional careers as social work, nursing, teaching, psychology, and business.

In the initial interview, all of the subjects reported high activity levels. Many women were hospital volunteers or active in women's clubs and community organizations. Most subjects also reported engaging in routine leisure activities requiring manual dexterity such as painting, gardening, reading, typing, and/or needlework. In the atrophy group, twenty-one subjects reported three or more manual leisure activities and four subjects reported engaging in fewer activities. In the normal group, twenty subjects performed a variety of leisure activities. All of the women were engaged in housekeeping tasks; however, eight subjects in the atrophy group received maid services at least once weekly. In the normal group, only two subjects paid a maid to perform heavy household tasks.

TABLE 1

COMPARISON OF THE TWO GROUPS IN EACH OF THE DEPENDENT VARIABLES

Variable[1]	Group 1 Range	Group 1 $\bar{X}$	Group 1 SD	Group 1 SEM	Group 2 Range	Group 2 $\bar{X}$	Group 2 SD	Group 2 SEM	t
Left grip[1]	30.00	32.04	9.11	1.86	30.00	42.00	6.66	1.36	-4.41***
Right grip[1]	36.00	35.32	9.67	1.97	33.00	46.84	7.81	1.59	-4.63***
Age[1]	18.00	75.08	4.37	0.89	17.00	73.28	4.73	0.97	1.40
2 MCP flexion[1]	35.00	81.52	8.33	1.70	12.00	88.24	3.32	0.68	-3.75***
3 MCP flexion[1]	25.00	82.20	7.91	1.61	10.00	88.00	3.30	0.67	-3.38**
4 MCP flexion[1]	35.00	81.96	8.44	1.72	20.00	85.56	5.82	1.19	-1.76
Hand height[1]	1.00	6.71	0.31	0.06	1.60	6.86	0.36	0.07	1.00

[1]Key to table is presented on page 55.

TABLE 1--Continued

Variable[1]	Group 1				Group 2				t
	Range	$\bar{X}$	SD	SEM	Range	$\bar{X}$	SD	SEM	
3rd digit length[1]	0.80	3.09	0.18	0.04	0.50	3.13	0.13	0.03	-0.79
Thenar atrophy[1]	1.00	0.60	0.50	0.10	1.00	0.12	0.33	0.07	4.00***
MCP extension[1]	1.00	0.40	0.50	0.10	1.00	0.12	0.33	0.07	2.33**
L 2-4 abduction[1]	1.80	3.98	0.45	0.09	1.30	4.36	0.40	0.08	-3.13**
R 2-4 abduction[1]	1.55	3.93	0.45	0.09	1.35	4.25	0.36	0.07	-2.79**
L 2-4 DIP[1]	3.60	7.96	0.96	0.20	2.80	8.73	0.88	0.18	-2.93**
R 2-4 DIP[1]	3.70	7.62	0.87	0.18	3.00	8.40	0.77	0.16	-3.32**
L 3-3 DIP[1]	3.70	3.44	0.96	0.20	2.30	4.05	0.62	0.13	-2.69**
R 3-3 DIP[1]	3.50	3.22	0.86	0.18	2.30	3.65	0.62	0.13	-2.02*
L radial dev.[1]	22.00	17.68	5.87	1.20	26.00	23.76	6.77	1.38	-3.39**

[1]Key to table is presented on page 55.

TABLE 1--Continued

Variable[1]	Group 1				Group 2				t
	Range	$\overline{X}$	SD	SEM	Range	$\overline{X}$	SD	SEM	
R radial dev.[1]	25.00	19.20	5.87	1.20	17.00	22.48	4.50	0.92	-2.22*
L ulnar deviation[1]	29.00	20.56	7.17	1.46	27.00	19.80	7.20	1.47	0.37
R ulnar deviation[1]	22.00	16.64	5.18	1.06	20.00	17.68	5.85	1.19	-0.67
L 3 deviation[1]	32.00	38.24	9.50	1.94	27.00	43.56	6.80	1.39	-2.28*
R 3 deviation[1]	27.00	35.84	8.22	1.67	26.00	40.16	7.27	1.48	-1.97

[1]Key to table is presented on page 55.

Note: Each of these t-tests had 48 degrees of freedom since there were twenty-five subjects in each group.

* $P < .05$
** $P < .01$
*** $P < .001$

KEY TO TABLE 1

L - left.

R - right.

2 MCP flexion - degrees of MCP flexion of index finger.

3 MCP flexion - degrees of MCP flexion of middle finger.

4 MCP flexion - degrees of MCP flexion of ring finger.

2-4 abduction - distance in inches between index and ring fingers.

2-4 DIP - Centimeters between distal IP joints of 2nd and 4th digits.

3-3 DIP - Centimeters of middle finger deviation.

radial deviation - angle of middle finger radial deviation.

ulnar deviation - angle of middle finger ulnar deviation.

3 deviation - angle of total middle finger deviation.

All of the subjects appeared relatively healthy for their age group. None of the women reported a history of rheumatoid arthritis, hand trauma, peripheral neuropathy, or any neurological deficits. Only six subjects in the study were diagnosed with diabetes mellitus of which four were in the atrophy group. Because of the widespread incidence of osteoarthritis in the older population, women with mild osteoarthritis were included in the study. Many subjects reported having isolated osteoarthritic joints especially in the knee and the hip.

Twelve women reported a history of osteoarthritis in the atrophy group and nine in the normal group. These subjects reported, however, that their hand functioning was not impaired by joint stiffness or pain due to this disorder at the time of testing. The distal joints of the fingers of older women often show arthritic changes. Six subjects in the atrophy group exhibited the presence of Heberden's nodes or deformity in some of their distal IP joints. In the normal group, four subjects possessed this typical characteristic of osteoarthritis.

Comparison of the Groups

The analysis of the data in comparing the two groups consisted of two-tailed *t*-tests. Originally, the investigator proposed conducting an analysis of covariance on each of the dependent variables with age as the covariate. This proposal was made as a method of statistically removing the influence of age from each of the variables because it was believed the group with hand atrophy would be significantly older in age than the normal group. Since the groups were not significantly different in age, this variable did not constitute any confounding of the interpretation of the results as initially envisioned, and it thus was no longer necessary to statistically control for the effects of age. Consequently, the more straight-forward _t_-tests were conducted to determine if significant differences existed between the groups on each of the dependent variables. Table 1 presents the descriptive statistics for each of the groups. _T_-tests comparing the groups on each of twenty-two dependent variables are also presented in this table. Since so many _t_-tests were conducted, the probability of spurious statistical significance increased among the family of mean differences examined. Thus, the actual probability of Type I error for the twenty-two _t_-tests was actually higher than the stated levels of .05, .01, or .001.

An inspection of Table 1 (page 52) reveals that the _t_-test for the comparison of nonpreferred grip strength mean of the atrophy group with the normal group was -4.41 ($p < .001$). The _t_-statistic of the preferred grip strength mean was 4.63 ($p < .001$). This indicates that the comparisons were statistically significant and that the first and second null hypotheses were rejected. A significant difference also existed between the groups with respect to bilateral grip strength. This is exemplified in Kellor's[1] table of norms for grip strength measured in pounds per square inch. The atrophy group performed at the twenty-fifth percentile while the normal group performed at the fiftieth percentile.

According to Bechtol,[2] various factors may influence grip strength including time of day and hand height when measured from the tip of the middle finger to the wrist crease. These two factors were measured in this study to determine if they may have constituted significant confounding influences on the results of the study. Fortunately, the two groups did not differ significantly on these variables. The mean time of test administration was between 4:00 and 4:30 p.m. for both groups. The mean hand height was 6.71 inches for subjects in the atrophy group and 6.86 inches for the normal group. The *t*-tests for the comparison of mean hand height and also of mean digit length between the groups were both nonsignificant. Because the two groups were not significantly different on these variables, it was

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[1]Kellor et al., Technical Manual of Hand and Dexterity Tests, p. 19.

[2]Bechtol, The Journal of Bone and Joint Surgery, p. 823.

assumed that the results of the study were not influenced by these potentially confounding variables.

Inspection of Table 1 (page 52) indicates these findings on the following variables: second digit MCP flexion ($\underline{t} = -3.75$, $\underline{p} < .001$), third digit MCP flexion ($\underline{t} = -3.38$, $\underline{p} < .05$), and fourth digit MCP flexion ($\underline{t} = -1.76$, ns). This indicates that the comparisons of the means were significant for the second and third digits, but was not significant for the fourth digit. The third null hypothesis concerning MCP flexion was thus rejected. A significant difference existed between the two groups with respect to the degrees of MCP joint flexion of the index and middle fingers while the IP joints remained extended. No significant difference existed, however, between the groups in ring finger MCP joint flexion.

Measurements from the finger-palmprints are also included in Table 1 (page 52). The t-test for the comparison of the presence of thenar atrophy in the atrophy group with the normal group was 4.00 ($\underline{p} < .001$). In addition, the t-test for the comparison of MCP extension of the atrophy group with the normal group was significant at the .05 level. It was found from the finger-palmprint data that a significant difference existed between the two groups with respect to the presence of thenar atrophy and limited MCP extension.

Table 1 (page 52) presents the comparison of the span of MCP abduction of the second and fourth digits between the groups. Two methods of measuring finger abduction were used for comparison of the groups: the distance between the centers of the distal IP joints and the distance between the finger tip spread. Both methods of measurement were significant at the .01 level and the fourth null hypothesis was therefore rejected. A significant difference existed between the groups with respect to abduction at the MCP joints of the index and ring fingers of either hand.

Finally, Table 1 (pages 52-53) presents *t*-statistics derived from comparing the groups in terms of middle finger lateral deviation. The *t*-test for comparison of mean centimeters of middle finger excursion (measured as distance from the distal IP joint centers) was significant at the .01 level for the nonpreferred hand and at the .05 level for the preferred hand. When comparing the angle means of middle finger excursion, the *t*-test was also significant ($p < .05$) but only for the nonpreferred hand. The *distance* of deviation was significantly different between the groups; however, the *angle* of deviation was significantly different only in the nonpreferred hand. Consequently, the fifth null hypothesis was rejected. It was thus found that a significant difference existed between the groups with respect to the lateral deviation of the third digit.

By dividing the angle of middle finger excursion into angles of radial and ulnar deviation, additional comparisons

TABLE 2

CORRELATIONS BETWEEN DEPENDENT VARIABLES FOR EACH GROUP

Variable	1	2	3	4	5	6	7	8
1. *L*.Grip		.81	-.35	-.02	.03	.25	.12	.11
2. *R* Grip	.87		-.25	.13	.21	.33	.19	.23
3. Age	-.05	-.02		.02	-.16	-.06	-.17	-.05
4. *R* 2 MCP Flexion	-.16	-.33	-.19		.74	.61	.41	.48
5. *R* 3 MCP Flexion	-.39	-.57	.12	.61		.84	.32	.48
6. *R* 4 MCP Flexion	-.18	-.26	.09	.57	.80		.34	.55
7. Hand Height	.17	.11	.04	.36	.17	.23		.77
8. Digit Length	.20	.18	-.10	.37	-.03	.07	.78	
9. Thenar Atrophy	-.19	-.33	-.37	.20	.19	-.04	-.26	-.33
10. MCP Extension	.13	.12	.19	-.03	.11	.07	.37	.52

Note: The atrophy group is above the diagonal. The normal group is below the diagonal. Correlations having absolute values equal to or greater than .28 and .36 are significant at the .05 and .01 levels of probability respectively based on two-tailed significance tests.

TABLE 2--Continued

Variable	1	2	3	4	5	6	7	8
11. L 2-4 Abduction	.23	.28	-.05	.27	-.06	-.02	.44	.71
12. R 2-4 Abduction	.37	.37	-.08	.26	.04	.09	.65	.72
13. L 2-4 DIP	.27	.30	-.04	.27	-.12	-.11	.47	.73
14. R 2-4 DIP	.35	.35	-.17	.27	.04	.07	.54	.64
15. L 3-3 DIP	-.12	.03	.08	.25	.24	.35	.23	.36
16. R 3-3 DIP	-.10	.03	.12	.15	.28	.34	.02	-.04
17. L Radial Deviat.	-.21	-.03	.04	.06	.08	-.06	.12	.08
18. R Radial Deviat.	-.59	-.38	.07	.09	.36	.33	-.19	-.16
19. L Ulnar Deviat.	-.08	-.03	.03	.10	.11	.28	-.10	.07
20. R Ulnar Deviat.	.12	.23	.10	-.12	-.02	.06	-.10	-.19
21. L Total Deviat.	-.30	-.06	.06	.04	.19	.23	.01	.15
22. R Total Deviat.	-.27	-.05	.12	-.04	.21	.26	-.20	-.25

TABLE 2--Continued

Variable	9	10	11	12	13	14	15
1. L Grip	-.04	-.03	.27	.27	.18	.26	-.01
2. R Grip	.13	-.01	.27	.27	.02	.14	.05
3. Age	.03	-.17	.32	.05	.38	.12	.17
4. R 2 MCP Flexion	.41	.22	.21	.22	.32	.13	.46
5. R 3 MCP Flexion	.41	.06	.07	.23	.11	.13	.41
6. R 4 MCP Flexion	.33	-.04	.02	.23	.02	.09	.34
7. Hand Height	.48	.49	.00	.34	.12	.33	.21
8. Digit Length	.41	.48	.12	.41	.18	.28	.41
9. Thenar Atrophy		.17	-.34	-.12	-.25	.13	-.08
10. MCP Extension	-.14		.13	.15	.20	.30	.25
11. L 2-4 Abduction	-.22	.35		.60	.97	.53	.67
12. R 2-4 Abduction	-.21	.40	.77		.60	.74	.65

TABLE 2--Continued

Variable	9	10	11	12	13	14	15
13. L 2-4 DIP	-.24	.33	.98	.74		.57	.72
14. R 2-4 DIP	-.18	.36	.77	.96	.75		.52
15. L 3-3 DIP	-.32	.09	.52	.50	.39	.49	
16. R 3-3 DIP	-.21	-.23	.08	.23	.02	.23	.43
17. L Radial Deviation	.09	.14	-.01	.28	-.06	.25	.34
18. R Radial Deviation	.27	-.01	-.14	-.11	-.25	-.13	.38
19. L Ulnar Deviation	-.32	-.16	.30	-.00	.21	.02	.52
20. R Ulnar Deviation	-.28	-.37	-.13	.02	-.13	.01	.06
21. L Total Deviation	-.25	-.03	.31	.28	.16	.27	.90
22. R Total Deviation	-.06	-.30	-.19	-.05	-.25	-.07	.28

TABLE 2--Continued

Variable	16	17	18	19	20	21	22
1. *L* Grip	.10	-.30	.06	.20	-.08	-.04	-.01
2. *R* Grip	.02	-.20	.01	.16	-.17	-.00	-.10
3. Age	-.07	.19	-.04	.06	-.05	.17	-.06
4. *R* 2 MCP Flexion	.27	.01	-.06	.41	.27	.31	.12
5. *R* 3 MCP Flexion	.30	-.03	.08	.43	.24	.30	.21
6. *R* 4 MCP Flexion	.17	-.11	.01	.36	.10	.21	.07
7. Hand Height	.14	-.30	-.15	.17	.18	-.06	.01
8. Digit Length	.27	-.21	-.14	.34	.24	.13	.05
9. Thenar Atrophy	-.21	-.33	-.08	-.04	-.33	-.23	-.27
10. MCP Extension	.22	-.20	.07	.34	.09	.14	.18
11. *L* 2-4 Abduction	.56	.27	.28	.70	.40	.69	.45
12. *R* 2-4 Abduction	.80	.25	.36	.50	.60	.53	.64

TABLE 2--Continued

Variable	16	17	18	19	20	21	22
13. L 2-4 DIP	.59	.27	.27	.70	.47	.70	.49
14. R 2-4 DIP	.48	.14	.44	.50	.18	.46	.43
15. L 3-3 DIP	.81	.54	.52	.81	.60	.94	.75
16. R 3-3 DIP		.50	.61	.60	.79	.76	.93
17. L Radial Deviation	.10		.59	.05	.31	.66	.62
18. R Radial Deviation	.44	.45		.33	.11	.62	.78
19. L Ulnar Deviation	.37	-.53	.11		.44	.79	.51
20. R Ulnar Deviation	.77	-.04	-.03	.23		.52	.70
21. L Total Deviation	.49	.44	.56	.53	.20		.77
22. R Total Deviation	.89	.24	.59	.25	.79	.51	

between the groups could be made. The *t*-test for the comparison of the mean angle of radial deviation of the third digit in each group was -3.39 ($p < .01$) for the nonpreferred hand and -2.22 ($p < .05$) for the preferred hand. The *t*-test for the comparison of the mean angle of ulnar deviation, however, was not significant. This indicated that a significant difference existed between the groups with respect to the angle of bilateral radial deviation but not ulnar deviation of the middle finger.

Interrelationships of the Variables

Pearson product-moment correlations were computed between the dependent variables within each group. These correlations are presented in Table 2. Inspection of this table indicates that numerous significant correlations existed within each of the groups. Of the 462 correlations which were computed 184 were found to be significant. Since so many correlations were computed, the probability of some of these being significant by chance alone is quite great. It is unlikely, however, that all of the statistically significant correlations were spurious. Consequently, the final two hypotheses were also rejected. Among the many significant correlations found in Table 2, there were several which have clinical significance. A summary of these follows.

More significant correlations between grip strength and other dependent variables existed in the normal group than in the group exhibiting dorsal interossei atrophy. A correlation of .35 ($p < .05$) was found between the nonpreferred grip and age in the atrophy group. In the normal group, however, bilateral grip strength was related to abduction of the index and ring fingers and radial deviation of the middle finger of the preferred hand.

No significant relationships existed between MCP joint flexion and any other dependent variable within the normal group, however, such correlations did occur in the other group. In the atrophy group, MCP joint flexion was significantly related to digit length ($p < .01$) and to the presence of thenar atrophy ($p < .05$).

An inspection of Table 2 also reveals other interesting interrelationships. Hand height and digit length were both significantly related to MCP joint extensibility in each group. In the atrophy group, thenar atrophy was significantly related to hand size measurements. Only in the normal group was hand height and digit length highly correlated with MCP abduction of the index and ring fingers ($p < .01$ and $p < .001$).

Possible statistical differences between parallel significant correlations of each group were tested. This was conducted using Fisher's[1] *r* to *z* transformation. It was found that only one pair of comparable correlations was significantly different. The correlations concerning the distance of the middle finger excursion between the preferred and the nonpreferred hand were .81 and .43 for the atrophied and nonatrophied groups, respectively. The difference between these correlations was significantly different ($z = 2.21$, $p < .05$), indicating that a stronger relationship existed between these variables in the atrophy group than in the normal group.

In Chapter V of this thesis, the investigator will present a summary of the study, draw conclusions, and offer recommendations for future research.

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[1]J. Bruning and B. Kintz, *Computational Handbook of Statistics*, 2nd ed. (Glenview, Ill.: Scott, Foresman, and Company, 1977), p. 214.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSION, DISCUSSION AND RECOMMENDATIONS FOR FUTURE STUDIES

Introduction

This chapter presents a summary of the study, findings of the study, a statement of conclusion, discussion, and recommendations for future studies.

Summary

The purpose of this study was to determine whether hand function among elderly women was altered due to dorsal interosseous muscle atrophy. Specifically, the investigator analyzed range of MCP joint motion, grip strength, and palmar contour and determined the relationships between hand function and bilateral dorsal interosseous atrophy.

Reviews of studies pertinent to hand intrinsic muscle function, dorsal interosseous muscle atrophy, and hand evaluations were presented. These studies included: an electromyographic investigation of intrinsic muscle control of the fingers conducted by Long, and electromyographic study of intrinsic muscle during power grip conducted by Long, Conrad, Hall, and Furler, a study of "intrinsic-minus" hands conducted by Srinivasan, a study concerned with dorsal interosseous muscle involvement in diabetic amyopathy conducted by Ellenberg, a similar study concerned with the first dorsal interosseous muscle conducted by Bienenstock, Davidson, and Forschner, a study describing the diabetic hand syndrome conducted by Jung et al., a study to assess hand skills in the elderly conducted by Bell, a study describing pictorial hand measurement conducted by Dworecka, an anthropometric study of the hand conducted by Garrett, a study concerned with the effects of age on the mobility of finger joints conducted by Barnett and Cobbold, a study to examine MCP joint mobility conducted by Loebl, a study concerned with digital deviation in the normal hand conducted by Iregbulem, Nicolle, and Calnan, and lastly a radiographic study of active MCP deviation conducted by Matheson, Sinclair, and Skene.

The present investigation evaluated the hand function of fifty active women over sixty-five years of age. All subjects were relatively healthy and lived in Chapel Hill, North Carolina during the Spring of 1979. Subjects were assigned to one of two groups according to the presence or absence of bilateral dorsal interossei muscle atrophy.

Measurements of each hand were collected by means of a Jamar dynamometer, a 180 degree goniometer, a hand outline, and a finger palmprint. The hands were assessed for grip strength, degrees of pure MCP flexion, hand height, digit length, MCP abduction, middle finger excursion, thenar atrophy and limited MCP extension. Prior to these hand evaluations, personal data were collected through interviews.

Raw data were coded on computer cards. Descriptive statistics and intercorrelations of all variables were determined by computer analyses of these data. Similarities and differences of the groups were presented in table form and summarized.

Findings of the Study

The following findings were based upon the data obtained from the present study:

1. The two groups were similar in age, hand height and digit length.

2. Dorsal interosseous atrophy did not significantly affect the angle of ulnar deviation in the middle finger.

3. Bilateral grip was significantly weaker in the group exhibiting dorsal interossei atrophy. This group performed at the 25th percentile for its mean age.

4. Subjects with dorsal interosseous atrophy had fewer degrees of pure MCP joint flexion in the index and middle fingers than did the normal group.

5. Subjects exhibiting dorsal interosseous atrophy possessed a higher incidence of thenar atrophy and limited metacarpophalangeal extension.

6. Fewer degrees of MCP abduction in the second and fourth fingers were observed in the group with hand atrophy than did the normal group.

7. The normal group demonstrated a greater range of middle finger excursion at the level of the distal IP joint. Also, the angle of excursion was greater but only in the non-preferred hand.

8. The subjects without hand atrophy could radially deviate the middle finger more than those subjects exhibiting dorsal interroseous atrophy.

9. With respect to the correlations between the dependent variables, in the atrophy group the following relationships were found: hand height and digit length were related to MCP extensibility, contour of the thenar eminence, and MCP joint flexion.

10. Only one pair of parallel correlations between groups was found to be significantly different. This variable concerned range of middle finger excursion between left and right hands.

Conclusion

The investigator concluded from the study that altered hand function was associated with dorsal interossei atrophy in hands from a population of geriatric women.

Discussion

The deficits in hand functioning were found to especially affect MCP joint mobility and power grip. The limitations exhibited by the atrophy group were subtle, but were evident and measurable when compared to a normal group. Functional deficits did not appear to exist, however. The women exhibiting hand atrophy who participated in the study did not report any difficulties with tasks requiring fine-motor coordination, but they were concerned with the appearance of their hands. Many of the women considered their hands "ugly" and were interested in performing exercise designed to hypertrophy their atrophied intrinsic hand musculature. Even though significant differences in hand function occurred between the two groups, it would be questionable whether any rehabilitative measures would be considered necessary to rectify a cosmetic problem unless a noticeable loss in function developed.

It was observed in the study that subjects having dorsal interossei atrophy performed fewer degrees of pure MCP flexion and possessed a significantly weaker grasp. With the mechanical disadvantages inherent in the decreased muscle fiber diameter of senile muscle atrophy, the interossei muscles would have less leverage to flex the MCP joints due to a smaller angle of pull. With less power and decreased leverage, one would expect pure MCP flexion to be, therefore, less in the group exhibiting hand atrophy. The weaker grip demonstrated by subjects with dorsal interossei atrophy would reflect the reduction in the interossei's role of generating power. The muscles of power grip are the interossei which are used as phalangeal abductors and MCP flexors. It should be noted that the mean grip strength of the atrophy group remained within normal limits, but that the group performed at the lower end of the range.

The investigator also observed from the study that women with visible bilateral dorsal hand atrophy demonstrated a greater incidence of thenar atrophy and limited phalangeal extensibility. These findings concur with the description of the diabetic hand syndrome. Finger clawing was a typical characteristic of intrinsic-minus hands, but was not documented specifically for senile muscle atrophy.

In general, dorsal interossei atrophy in older women appeared to limit MCP joint abduction. A few interesting exceptions were, however, noted: the middle finger had limited lateral deviation but only in the radial direction, and only the preferred hand demonstrated a decreased angle of middle finger excursion. It has been speculated by other investigators that collateral ligament length at the MCP joint is related to angle of deviation and that little disparity exists between ulnar and radial deviation in normal females. From this study, the investigator suggested that lateral digital deviation was decreased secondary to weak, atrophied interossei muscles.

Finally, the investigator found relationships between the various measurements of the atrophied hand. Hand height and digit length were related to the following: presence of thenar atrophy, limited MCP extensibility, and limited MCP flexion. Only limited MCP extensibility was related to hand height and digit length in the normal group. It was questionable whether these relationships were clinically meaningful.

Progressive deterioration of glucose tolerance in the aged is a well known phenomenon. Some sources have indicated that the incidence of diabetes among the aged could be up to 50 percent of elderly population. One source concluded that women become more frequently diabetic in old age. These authors found that the proportion of women suffering from senile diabetes was 26 percent and concluded that senile diabetes may be related to pancreatic aterio-sclerosis.[1] The criteria for diagnosing diabetes in persons over sixty years of age have not been well established, but atrophy of the dorsal interossei muscles have proven to be a diagnostic cue to undetected diabetes mellitus. From the

[1] L. Motta, A. Lombardo, and A. Tribulato, "Diabete Senile: Aspetti Eziopathogenetici," Giornale Di Gerontologia 25 (1977): 227-236.

findings of the study, it is concluded that visible bilateral dorsal interosseous atrophy in the aged does affect hand functioning. Its occurrence in the geriatric population may be as frequent as senile diabetes and should warrant consideration for early instruction in hand exercise designed to maintain or to improve strength and active range of motion.

Recommendations for Future Studies

The following recommendations are suggested for additional investigations:

1. Conduct a study in which the power of abduction is measured using a lateral push/pull gauge to test the dorsal interossei muscles.

2. Conduct a similar study which excludes all persons who report arthritic joint changes and which is designed for multivariate statistics.

3. Conduct a treatment study in which a systematic effort is made to improve the hand functioning of subjects exhibiting dorsal interosseous atrophy.

APPENDIX A

LETTERS OF PERMISSION

Personal information is here. To protect individuals, we have omitted this page. Pagination may be different as a result.

APPENDIX B

RESEARCH CONSENT FORM

RESEARCH CONSENT FORM

I am willing to participate in the research project entitled Muscle Atrophy of the Dorsal Interossei in the Geriatric Hand being conducted by Mary Reuterfors, graduate student from Texas Woman's University.

I authorize Mary Reuterfors to perform the following procedures:

Visually inspect the hand for muscle atrophy.
Gather available medical and social history.
Measure grip strength by squeezing an instrument called a dynamometer.
Measure joint motion of knuckles while fingers remain straight.
Draw an outline of both hands on paper using a pencil.
Smooth hand lotion on hands and press them palm-down on a paper to see imprint of palms.

I understand that the above procedures may involve several possible discomforts such as some joint discomfort or slightly elevated blood pressure when squeezing the dynamometer. I am aware that my participation in this research may provide a more complete understanding of the aging hand. This investigation hopes to provide a rationale for the necessity of rehabilitative measures to improved hand functioning when muscle atrophy is present.

An offer to answer all of my questions regarding the study has been made. I understand that I may terminate my participation in the study at any time.

______________________________ Subject's Signature

________________ Date

APPENDIX C

ATROPHY GROUP RAW DATA

APPENDIX C

ATROPHY GROUP RAW DATA

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
01	1:00	L 35	79	L 84	L 85	L 84	6.5	3.1	L 3.25	L 6.3	L 2.6	L 17	L 13	L 30	+-
		R 48		R 82	R 87	R 90			R 3.6	R 7.1	R 2.7	R 15	R 15	R 30	
02	11:00*	L 44	69	L 83	L 75	L 72	7.0	3.15	L 3.85	L 7.7	L 2.1	L 13	L 10	L 23	-+
		R 45		R 83	R 75	R 76			R 3.75	R 7.4	R 2.5	R 15	R 14	R 29	
03	7:00	L 39	69	L 68	L 70	L 80	6.5	2.8	L 3.35	L 6.4	L 1.7	L 12	L 12	L 24	--
		R 30		R 55	R 72	R 75			R 4.0	R 7.8	R 3.1	R 24	R 16	R 40	
04	5:00	L 25	79	L 90	L 90	L 90	7.1	3.25	L 4.2	L 8.7	L 4.3	L 25	L 20	L 45	++
		R 25		R 90	R 90	R 90			R 4.5	R 8.9	R 3.8	R 25	R 17	R 42	
05	7:00	L 43	68	L 82	L 90	L 90	6.45	3.0	L 3.9	L 7.4	L 3.5	L 25	L 18	L 43	--
		R 45		R 79	R 90	R 89			R 3.8	R 7.4	R 2.8	R 18	R 14	R 32	

APPENDIX C--Continued

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
06	4:00	L 25	80	L 75	L 80	L 80	6.5	3.05	L 4.7	L 9.2	L 3.9	L 22	L 23	L 45	--
		R 29		R 75	R 65	R 75			R 4.5	R 8.8	R 3.3	R 15	R 18	R 33	
07	5:00	L 40	77	L 90	L 90	L 90	6.8	3.1	L 3.9	L 8.0	L 2.7	L 7	L 22	L 29	+-
		R 45		R 90	R 90	R 90			R 3.3	R 6.6	R 2.1	R 5	R 17	R 22	
08	8:00	L 25	79	L 65	L 60	L 60	6.0	2.55	L 4.05	L 8.1	L 2.3	L 20	L 14	L 34	--
		R 25		R 70	R 65	R 55			R 3.4	R 6.9	R 2.3	R 16	R 14	R 30	
09	4:30	L 50	71	L 90	L 90	L 90	7.0	3.3	L 4.4	L 9.0	L 5.4	L 16	L 39	L 55	++
		R 59	R 90	R 90	R 90	R 90			R 4.8	R 9.9	R 4.7	R 28	R 20	R 48	
10	3:00	L 24	75	L 82	L 75	L 65	7.0	3.0	L 3.9	L 8.1	L 3.4	L 17	L 20	L 37	++
		R 26		R 90	R 85	R 79			R 4.05	R 8.1	R 3.9	R 21	R 21	R 42	
11	4:00	L 39	81	L 90	L 90	L 90	6.6	3.25	L 5.05	L 9.9	L 4.9	L 14	L 38	L 52	-+
		R 34		R 90	R 90	R 90			R 4.4	R 8.5	R 4.1	R 23	R 18	R 41	

APPENDIX C--Continued

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
12	7:30	L 24	86	L 75	L 80	L 80	6.5	3.05	L 4.45	L 9.2	L 4.6	L 29	L 20	L 49	--
		R 30		R 80	R 79	R 81			R 3.85	R 7.4	R 3.9	R 24	R 22	R 46	
13	5:00	L 20	75	L 80	L 85	L 80	6.3	3.05	L 3.4	L 6.6	L 3.0	L 21	L 14	L 35	+-
		R 23		R 80	R 85	R 80			R 3.8	R 7.6	R 2.9	R 21	R 13	R 34	
14	7:00	L 24	75	L 82	L 83	L 83	7.0	3.2	L 3.5	L 6.8	L 2.7	L 10	L 20	L 30	+-
		R 26		R 83	R 87	R 90			R 3.3	R 6.6	R 1.6	R 10	R 11	R 21	
15	1:00	L 38	74	L 90	L 90	L 90	6.8	3.05	L 4.3	L 8.5	L 4.4	L 25	L 26	L 51	+-
		R 45		R 85	R 90	R 90			R 4.1	R 8.0	R 3.9	R 30	R 16	R 46	
16	7:00	L 20	74	L 83	L 75	L 73	6.8	3.1	L 4.15	L 8.6	L 4.3	L 18	L 31	L 49	-+
		R 25		R 80	R 81	R 79			R 3.95	R 7.7	R 3.7	R 18	R 26	R 44	
17	11:00*	L 25	75	L 83	L 78	L 75	6.6	3.15	L 3.35	L 6.7	L 2.8	L 14	L 17	L 31	++
		R 30		R 76	R 76	R 83			R 3.25	R 6.2	R 2.4	R 20	R 11	R 31	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
18	11:00*	L 33	74	L 77	L 75	L 69	6.1	2.75	L 4.1	L 7.9	L 3.7	L 27	L 21	L 48	--
		R 40		R 77	R 76	R 76			R 3.5	R 6.6	R 3.6	R 30	R 13	R 43	
19	12:00	L 22	76	L 85	L 85	L 75	7.0	3.15	L 3.75	L 8.1	L 4.2	L 23	L 19	L 42	+-
		R 25		R 90	R 86	R 82			R 4.15	R 8.2	R 3.7	R 21	R 21	R 42	
20	7:00	L 40	74	L 75	L 83	L 75	7.0	3.35	L 4.4	L 8.8	L 3.8	L 17	L 22	L 39	++
		R 36		R 73	R 80	R 70			R 4.2	R 8.3	R 3.9	R 19	R 20	R 39	
21	7:00	L 38	76	L 90	L 90	L 90	6.4	3.0	L 4.2	L 8.4	L 2.5	L 10	L 20	L 30	+-
		R 35		R 90	R 90	R 90			R 3.9	R 7.8	R 2.6	R 17	R 12	R 29	
22	11:00*	L 20	75	L 80	L 76	L 79	7.0	3.3	L 3.3	L 6.7	L 2.8	L 14	L 14	L 28	++
		R 40		R 80	R 76	R 79			R 3.5	R 7.1	R 2.3	R 15	R 10	R 25	
23	12:30	L 45	78	L 70	L 75	L 80	7.1	3.15	L 4.1	L 8.1	L 2.6	L 11	L 15	L 26	+-
		R 50		R 75	R 75	R 80			R 4.2	R 8.0	R 2.4	R 15	R 10	R 25	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
24	5:00	L 30	69	L 85	L 85	L 85	6.8	3.1	L 3.95	L 7.8	L 3.5	L 15	L 24	L 39	++
		R 32		R 90	R 85	R 80			R 3.7	R 7.3	R 3.2	R 20	R 15	R 35	
25	11:30*	L 33	69	L 90	L 90	L 90	6.8	3.3	L 4.1	L 8.1	L 4.3	L 20	L 22	L 42	--
		R 35		R 90	R 90	R 90			R 4.8	R 6.4	R 5.1	R 15	R 32	R 47	

*Time of data collection in the a.m. All others are in the p.m.

L designates left or nonpreferred hand.

R designates right or preferred hand.

APPENDIX D

NORMAL GROUP RAW DATA

APPENDIX D

NORMAL GROUP RAW DATA

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
01	7:00	L 50	82	L 89	L 90	L 90	7.15	3.03	L 3.95	L 7.9	L 4.0	L 21	L 17	L 38	--
		R 50		R 90	R 90	R 90			R 4.15	R 7.9	R 4.2	R 21	R 21	R 42	
02	7:00	L 50	73	L 85	L 90	L 81	6.9	3.2	L 4.5	L 8.8	L 4.2	L 20	L 24	L 44	-+
		R 58		R 84	R 82	R 84			R 4.3	R 8.5	R 2.8	R 21	R 10	R 31	
03	2:00	L 43	82	L 88	L 90	L 80	7.45	3.3	L 4.9	L 10.1	L 3.7	L 23	L 15	L 38	-+
		R 45		R 90	R 89	R 86			R 4.6	R 8.9	R 3.0	R 21	R 10	R 31	
04	1:00	L 50	75	L 80	L 79	L 78	6.4	3.0	L 4.05	L 8.3	L 3.2	L 15	L 20	L 35	--
		R 58		R 78	R 80	R 73			R 4.0	R 7.7	R 3.3	R 15	R 24	R 39	
05	8:00	L 41	68	L 85	L 90	L 85	6.9	3.1	L 4.15	L 8.3	L 4.0	L 25	L 18	L 43	--
		R 45		R 88	R 89	R 83			R 4.17	R 8.3	R 3.7	R 21	R 16	R 37	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
06	7:00	L 40	77	L 90	L 90	L 90	7.2	3.2	L 4.9	L 10	L 4.4	L 28	L 16	L 44	--
		R 50		R 90	R 90	R 90			R 4.6	R 9.1	R 3.9	R 21	R 21	R 42	
07	12:30	L 50	69	L 86	L 83	L 85	7.2	3.25	L 4.7	L 9.5	L 4.0	L 26	L 15	L 41	--
		R 53		R 89	R 84	R 80			R 4.5	R 8.6	R 3.0	R 13	R 19	R 32	
08	11:00*	L 41	73	L 90	L 88	L 87	6.8	3.1	L 4.25	L 8.3	L 4.3	L 40	L 10	L 50	+-
		R 46		R 90	R 89	R 80			R 4.4	R 8.5	R 3.6	R 29	R 17	R 46	
09	12:30	L 38	79	L 90	L 90	L 90	6.5	3.1	L 4.48	L 8.8	L 4.4	L 14	L 35	L 49	--
		R 45		R 90	R 90	R 90			R 3.65	R 7.1	R 3.8	R 25	R 20	R 45	
10	3:00	L 41	69	L 90	L 90	L 90	6.1	3.0	L 4.1	L 8.1	L 4.3	L 28	L 20	L 48	--
		R 46		R 90	R 90	R 90			R 4.2	R 8.6	R 4.7	R 25	R 29	R 54	
11	2:00	L 35	68	L 90	L 90	L 90	6.55	2.9	L 4.0	L 7.9	L 3.6	L 22	L 15	L 37	+-
		R 39		R 90	R 90	R 90			R 3.95	R 8.0	R 3.0	R 26	R 9	R 35	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
12	7:00	L 25	77	L 88	L 88	L 80	6.5	3.0	L 4.3	L 8.4	L 4.8	L 26	L 26	L 52	--
		R 27		R 89	R 90	R 85			R 3.95	R 7.9	R 3.1	R 23	R 11	R 34	
13	11:00	L 42	66	L 90	L 85	L 83	6.8	3.1	L 4.3	L 7.8	L 3.8	L 26	L 20	L 46	--
		R 54		R 88	R 85	R 86			R 3.95	R 7.7	R 3.4	R 24	R 19	R 43	
14	7:00	L 37	76	L 90	L 88	L 90	7.0	3.1	L 3.75	L 7.6	L 3.0	L 20	L 12	L 32	--
		R 41		R 90	R 90	R 90			R 3.9	R 7.3	R 3.4	R 25	R 14	R 39	
15	6:00	L 30	71	L 90	L 90	L 90	7.35	3.3	L 4.7	L 9.3	L 5.0	L 20	L 37	L 57	--
		R 36		R 90	R 90	R 90			R 4.6	R 8.8	R 5.1	R 30	R 26	R 56	
16	1:00	L 43	72	L 90	L 90	L 90	6.9	3.2	L 4.65	L 9.3	L 4.9	L 20	L 30	L 50	--
		R 44		R 90	R 90	R 88			R 4.25	R 8.5	R 3.4	R 24	R 10	R 34	
17	5:30	L 50	68	L 90	L 90	L 90	7.2	3.3	L 4.85	L 9.9	L 4.6	L 25	L 20	L 45	--
		R 55		R 90	R 90	R 90			R 4.7	R 9.4	R 3.0	R 20	R 10	R 30	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
18	7:00	L 45	70	L 83	L 80	L 70	6.95	3.25	L 4.85	L 10.3	L 3.6	L 19	L 17	L 36	--
		R 53		R 90	R 80	R 70			R 4.4	R 9.1	R 3.5	R 17	R 17	R 34	
19	3:00	L 40	65	L 89	L 90	L 90	6.5	3.05	L 4.15	L 8.3	L 2.7	L 14	L 16	L 30	+-
		R 35		R 90	R 90	R 85			R 3.8	R 7.6	R 3.3	R 22	R 14	R 36	
20	8:00	L 55	73	L 90	L 90	L 90	6.95	3.1	L 5.05	L 10.0	L 4.5	L 15	L 32	L 47	--
		R 60		R 90	R 90	R 90			R 4.95	R 10.1	R 4.7	R 19	R 26	R 45	
21	4:00	L 40	78	L 89	L 87	L 90	6.6	3.0	L 4.05	L 8.0	L 4.5	L 30	L 20	L 50	--
		R 50		R 86	R 87	R 90			R 3.95	R 7.8	R 4.7	R 29	R 25	R 54	
22	11:00*	L 45	75	L 90	L 90	L 90	7.0	3.15	L 3.8	L 7.5	L 3.9	L 21	L 20	L 41	--
		R 45		R 90	R 90	R 90			R 4.25	R 8.5	R 3.5	R 18	R 20	R 38	
23	3:00	L 40	77	L 80	L 85	L 75	6.4	3.0	L 4.3	L 8.4	L 4.2	L 36	L 15	L 51	--
		R 50		R 80	R 85	R 76			R 4.25	R 8.4	R 3.8	R 30	R 15	R 45	

S	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
24	7:00	L 39	77	L 90	L 85	L 83	7.0	3.0	L 3.85	L 7.8	L 3.0	L 24	L 14	L 38	--
		R 41		R 84	R 90	R 83			R 3.8	R 7.6	R 3.3	R 18	R 23	R 41	
25	6:00	L 40	72	L 90	L 85	L 85	7.7	3.4	L 4.8	L 9.6	L 4.7	L 36	L 11	L 47	-+
		R 45		R 90	R 90	R 90			R 5.0	R 10.0	R 4.0	R 25	R 16	R 41	

*Time of data collection in the a.m. All the rest are in the p.m.

L designates left or nonpreferred hand.

R designates right or preferred hand.

APPENDIX E

KEY TO RAW DATA TABLES

KEY TO RAW DATA TABLES

Variable

1. Time of test administration.
2. Grip strength in pounds per sq. inch.
3. Age in years.
4. Degrees of MCP flexion in the index finger.
5. Degrees of MCP flexion in the middle finger.
6. Degrees of MCP flexion in the ring finger.
7. Hand height in inches.
8. Third digit length in inches.
9. Abduction of second and fourth digits in inches.
10. Centimeters between distal IP joints of 2 and 4 digits.
11. Centimeters of middle finger excursion.
12. Angle of middle finger radial deviation.
13. Angle of middle finger ulnar deviation.
14. Angle of full middle finger deviation.
15. Presence of thenar atrophy and limited MCP extension respectively.

APPENDIX F

MCP GONIOMETRIC MEASUREMENTS OF INDEX FINGER

MCP GONIOMETRIC MEASUREMENTS OF

INDEX FINGER

Normal Group

Subject	Nonpreferred Hand			Preferred Hand		
	Trials (1)	Trials (2)	Trials (3)	Trials (1)	Trials (2)	Trials (3)
1	85	92	90	88	88	92
2	80	85	85	80	84	84
3	85	75	85	85	90	90
4	80	78	79	76	76	80
5	85	90	90	90	85	90
6	95	100	100	96	100	100
7	85	86	86	90	85	87
8	90	90	90	90	90	90
9	90	95	100	89	95	99
10	90	90	90	95	95	95
11	94	90	90	92	100	104
12	75	85	90	87	90	87
13	90	90	90	90	85	90
14	90	90	90	90	85	84
15	90	90	90	90	90	90
16	80	90	90	90	90	90

Normal Group--Continued

Subject	Nonpreferred Hand			Preferred Hand		
	Trials			Trials		
	(1)	(2)	(3)	(1)	(2)	(3)
17	90	90	90	90	90	90
18	80	85	85	90	90	90
19	88	89	89	85	95	81
20	90	90	90	85	90	90
21	88	88	90	80	85	86
22	90	100	95	100	102	100
23	75	80	80	80	75	80
24	90	90	90	80	82	84
25	90	90	90	90	90	90
			Atrophy Group			
1	81	86	86	80	84	84
2	65	77	75	82	84	84
3	65	65	70	55	50	55
4	90	85	90	90	90	90
5	80	83	83	79	79	79
6	70	75	75	72	75	75
7	95	90	90	90	105	100
8	45	45	45	60	56	70
9	90	92	92	95	91	95

Atrophy Group--*Continued*

Subject	Nonpreferred Hand Trials (1)	(2)	(3)	Preferred Hand Trials (1)	(2)	(3)
10	80	82	81	90	90	90
11	90	95	90	80	85	90
12	75	75	75	70	80	80
13	90	90	90	90	90	90
14	82	76	80	85	82	85
15	80	90	85	75	85	80
16	85	80	80	80	80	80
17	85	80	80	75	77	80
18	75	80	80	75	80	80
19	70	85	80	85	90	90
20	75	75	75	70	75	75
21	90	90	90	85	90	90
22	75	76	80	60	45	55
23	70	70	70	70	70	70
24	90	86	90	85	80	85
25	96	98	95	80	95	97

APPENDIX G

FORMULAS USED IN THE STUDY

FORMULAS USED IN THE STUDY

$\underline{T}$- test: $$\underline{t} = \frac{M_1 - M_2}{\sqrt{\frac{s^2}{N_1} + \frac{s^2}{N_2}}}$$

Computation formula for
Pearson's Correlation:

$$r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{N\Sigma X^2 - (\Sigma X)^2}\ \sqrt{N\Sigma Y^2 - (\Sigma Y)^2}}$$

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