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*Gripping Strength Measurements  
of Children for Product  
Safety Design*

CLYDE L. OWINGS, M.D., Ph.D.

RICHARD H. NORCUTT, M.S.

RICHARD G. SNYDER, Ph.D.

D. HENRY GOLOMB, M.S.

KATHIE Y. LLOYD, B.S.

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GRIPPING STRENGTH MEASUREMENTS OF CHILDREN  
FOR PRODUCT SAFETY DESIGN

CLYDE L. OWINGS, M.D., Ph.D.  
Department of Pediatrics and Communicable Diseases  
Department of Electrical and Computer Engineering

RICHARD H. NORCUTT, M.S. (Bioengineering)  
Department of Pediatrics and Communicable Diseases

RICHARD G. SNYDER, Ph.D.  
Biomedical Department, Highway Safety Research Institute  
Department of Anthropology

D. HENRY GOLOMB, M.S.  
Highway Safety Research Institute

KATHIE Y. LLOYD, B.S.  
Department of Pediatrics and Communicable Diseases

THE UNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGAN 48109

Prepared for:

The Consumer Product Safety Commission  
5401 West Bard Avenue  
Bethesda, Maryland 20207



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## 1.0 INTRODUCTION

This report describes isometric strength measurements of hand and upper extremity function obtained on a group of children, age two through ten. Three-point pinch, five-point pinch, and squeeze or power grip were measured at different degrees of hand closure, corresponding to exertions on objects between two and nine centimeters size. The torque capability around the elbow both for flexion and extension was measured at joint angles between  $67.5^{\circ}$  and  $180^{\circ}$ .

Over three hundred fifty children between the ages of two and eleven served as subjects for hand measurements. The group was chosen, for the most part, from children who had participated in a nationwide anthropometric study of over 8,000. Studies of elbow strength were done on 104 boys and girls.

## 1.1 Background

An investigation of the strength characteristics of U.S. children for product safety design was reported in 1975 (162). A new measurement system was developed and validated for obtaining isometric strength measurements, expressed as torques, at the major joint centers for children. The age range studied was between two and eleven years, and over five hundred children were measured. The torque values were obtained at a specified anatomic position, but only a single position was used for most measurements. Also force capabilities for squeeze, two point pinch, three point pinch, five point pinch, and lateral pinch were measured with each at a single degree of hand closure. A computer based model for the prediction of strength from these data was developed.

This report represents a continuation of the measurement techniques described above and an expansion of the quantitative strength data in two areas:

- 1) the elbow at different angles for flexion and extension
- 2) the hand at different degrees of hand closure for squeeze, three point pinch, and five point pinch.

Both contain new data that relate strength and the position of measurement.

Rather complete anthropometry was obtained on the subjects of this investigation. Extensive measurements of hand dimensions were included in order to investigate the relationship between

hand size and strength.

The hand, with its opposable thumb, is a mechanically complex region of the body that is responsible for fine control movements and, on occasion, can supply considerable power. Many tests of manual dexterity have been developed to evaluate hand movements in adults (117, 115, 206). Many methods have been used to measure hand strength, also in adults, but there is no single test that completely describes hand strength.

The situation is even more difficult to characterize for children who have different size hands at different ages. As a child grows his hand becomes both larger and stronger. Very little information is available on how this growth affects strength. Indeed, many measurements have been obtained with little attention devoted to the size of the hand. Most measurements of gripping strength fail to specify the size of the surfaces being gripped to secure a strength value (74, 134, 160).

One of the most popular instruments for gripping strength measurements, the Jamar dynamometer, can be adjusted to vary the spacing between the gripping surfaces. Only one study (151) was found that evaluated the optimum setting of an adjustable dynamometer (Stoelting). In this study, Montoye and Faulkner concluded "a slight advantage is gained particularly for subjects with large or small hand size, through the use of an adjustable grip dynamometer." Subjects ranged in age between 4 and 52 years but the distance between gripping surfaces ranged from 4.25 cm. to 6.5 cm. The data was only reported according to hand size, and not age. Perhaps hand strength

depends upon more than just hand size. For example, a growing ten year old boy might have the same hand breadth and hand length as a small fifty year old female, but should one expect the same strength capability from both?

The size of a test fixture and the size of the hand it measures interact in several ways. Obviously, a small hand may not be large enough to grasp a large object, but the converse also causes problems. For a large hand, a rod becomes more difficult to grasp as its size becomes smaller. Closure of the fingers around an object, together with the compressibility of tissue, interferes with the ability to transmit force to an object. The force measured for large hands is reduced as the gripping span is decreased in Montoye's and Faulkner's study (151). The loading forces on tissue become more important for smaller objects since the force per unit area increases. For all of these reasons, an adult would have much more difficulty climbing a 1/8" diameter vertical rod than a 2" diameter vertical rod.

The most comprehensive measurement of gripping strength contains data on 6000 males and females but only between the ages of 10 years and 69 years (152). This study measured 82% of the eligible age range in an entire community, as well as including a measure of arm strength.

Many studies have reported strength measurements about the elbow, but most were obtained at a single position. The measurement methods used have been previously discussed (162)

but suffer from several defects. The poor dynamic response of measurements using a cable tensiometer make it difficult to evaluate the effect of "explosive" strength. The effect of experimenter expectation (183) has been mentioned and is an uncontrolled variable in many studies. The subjective nature of numeric evaluation from chart records introduces an additional variable in the few studies that use strain gages.

Singh and Karpovitch (197) measured college students and reported the torque generated about the elbow joint for both flexion and extension. The instrument used a large electric motor which moved the arm through its range of motion, as an electrogoniometer measured the joint angle. This technique more nearly approximates isotonic strength rather than isometric strength.

In an earlier study Williams and Stutzman measured strength variation through the range of joint motion with a cable tensiometer (231). The results were reported for "college men" and are interesting mainly for the shape of the curves.

Since no precise data was available for children, this study was undertaken to measure the variation of strength about the elbow at different joint angles for both flexion and extension. These data are needed to improve the prediction process for strength in a variety of positions.

The safety implications of strength are numerous. This is especially true for children who may not be aware of their own limitations. The force transmitted to an object may be sufficient to move the object but not large enough to allow for com-

fortable control. A child who lifts a floor lamp may not be strong enough to prevent it from toppling. As loss of control is more likely to result in injury to the individual, grasping force is important in estimating the hazard for injury of a situation.

## 1.2 Objectives and Scope

The objectives of this study were:

- 1) To design and construct a device for the measurement of hand strength in children between the age of three and ten years. The device would have the capacity to measure three point pinch, five point pinch, and squeeze at different degrees of hand closure.
- 2) To develop data acquisition programs that control the operation of both the new device and the existing strength chair.
- 3) To obtain gripping strength measurements on 350 children ranging in age from two to ten years. To include:
  - a) Three point pinch at one centimeter increments between 2 cm. and 9 cm.
  - b) Five point pinch at one centimeter increments between 2 cm. and 9 cm.
  - c) Squeeze at one centimeter increments between 2 cm. and 7 cm.
- 4) To obtain measurements of elbow flexion strength and elbow extension strength on a sub-population of 100 children. The strengths are measured at the following angles of elbow flexion: 67.5°, 90°, 112.5°, 135°, 157.5°, and 180° (full extension).
- 5) To analyze and statistically reduce the data in such a manner as to be convenient for product safety design.

## 2.0 METHODS AND TECHNIQUES

### 2.1 Design of the Study

There are several ways to measure and report the results of a strength test. Strength may be considered as a force acting at a distance so that a complete description must include the magnitude of the force and the direction and location at which it was measured. An alternate way to present the same information uses the rotational equivalent, or torque, around a joint center of rotation. Both methods of reporting strength are used in this report.

The measurements of elbow flexion and elbow extension are most conveniently expressed as the torque about the elbow center of rotation. This is the same method used in the previous report (162). All torques are expressed in (Kgf-cm) Kilogram force-centimeters.

For gripping strength measurements it is more appropriate to report the force magnitude and direction since the transducer is adjustable to represent standard size objects between 2 and 9 centimeters. The immense mechanical complexity of the hand with a large number of joints would require that the position of each joint be known in order to express the measurements as torques. All forces are expressed in (Kgf) Kilogram force. The direction of the force is reported as the angle formed with the centerline of the grip transducer.



## 2.2 Elbow Transducer: Design and Function

The transducer used to measure isometric elbow flexion/extension at different elbow angular positions was part of a versatile "strength chair" previously designed and used to make similar child strength measurements at other body joints. (Figs. 2,3). The chair fits the child sitting in it like an exoskeleton for the right half of the body. The upper and lower limbs rest on padded metal bars whose articulated lengths are adjustable to fit any size child in the 2 to 10 year age range. (Fig. 4). The child's trunk and limbs are snugly strapped to supporting bars where their strength can be measured by strain gages. All the electrical signals are amplified and fed via a 12 bit A/D converter to a Nova 1220 digital computer where special programs control data acquisition (Fig. 1). Also while in the chair, the child's weight can be measured by load cells.

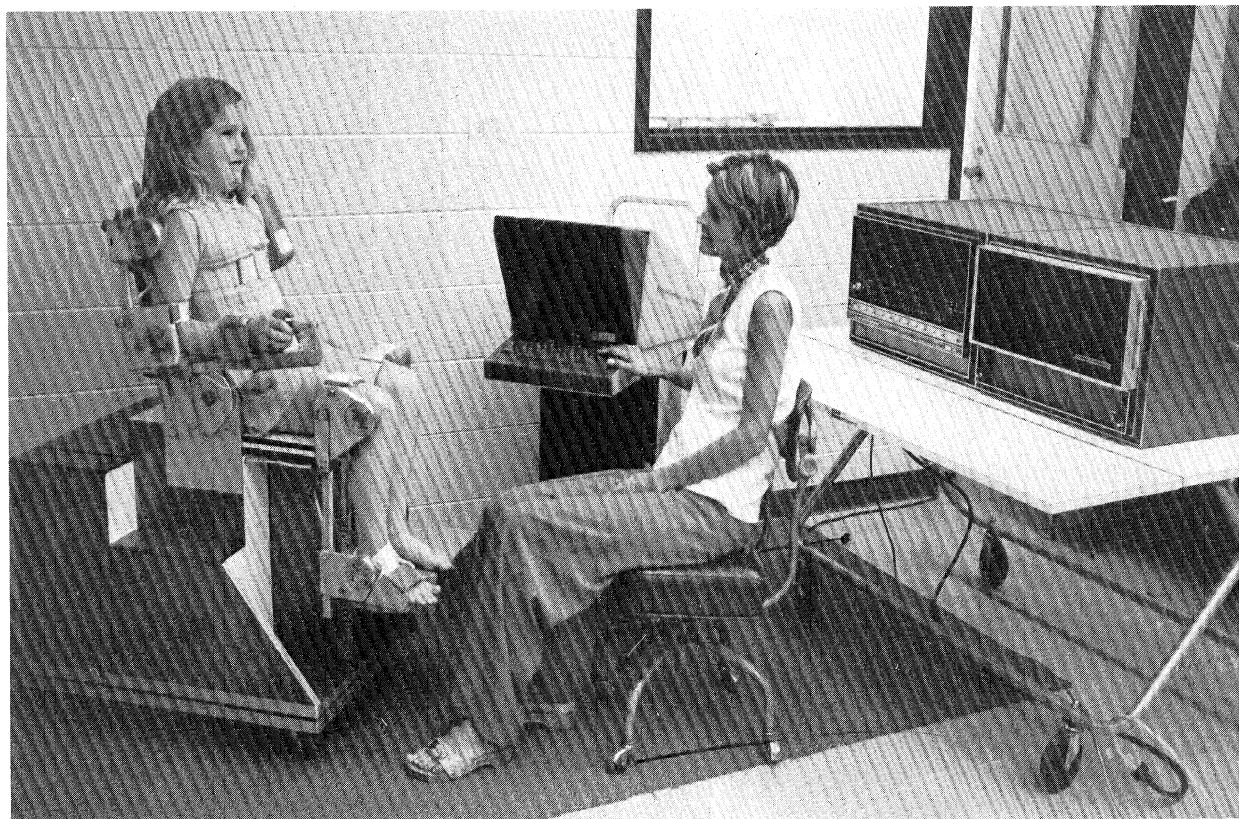


Figure 1 Complete Measurement System

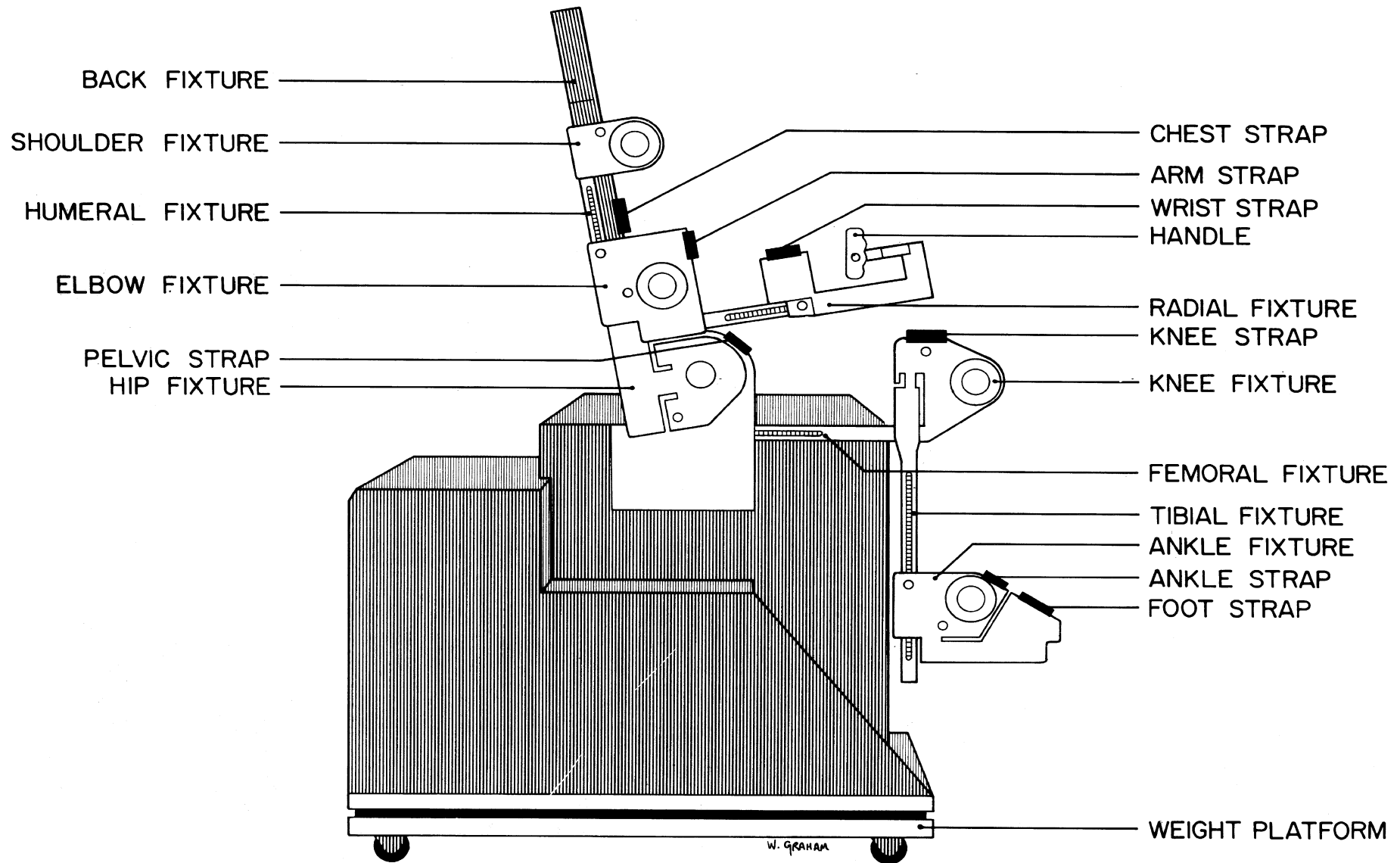


Figure 2 Side View of Chair

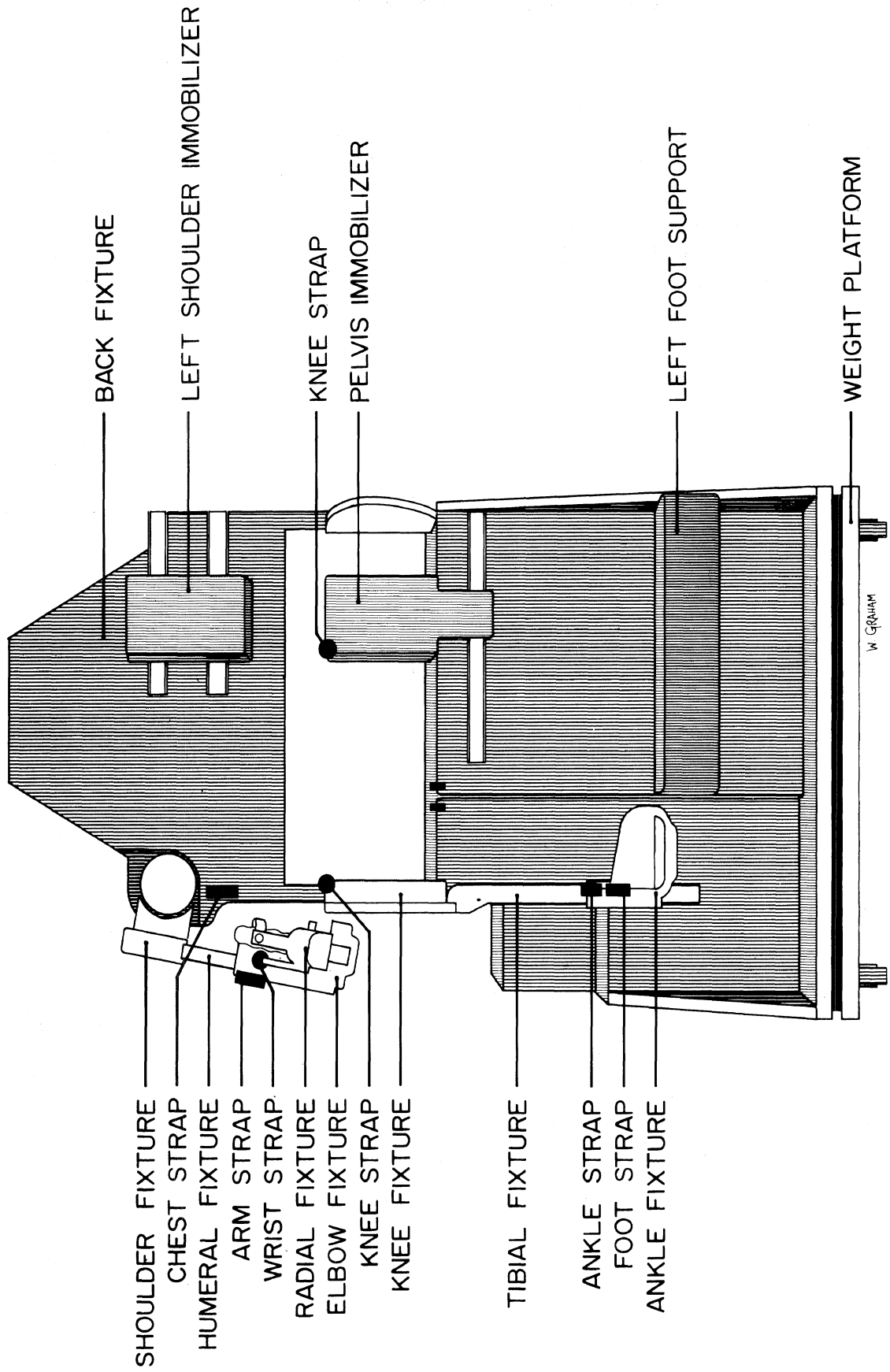


Figure 3 Front View of Chair

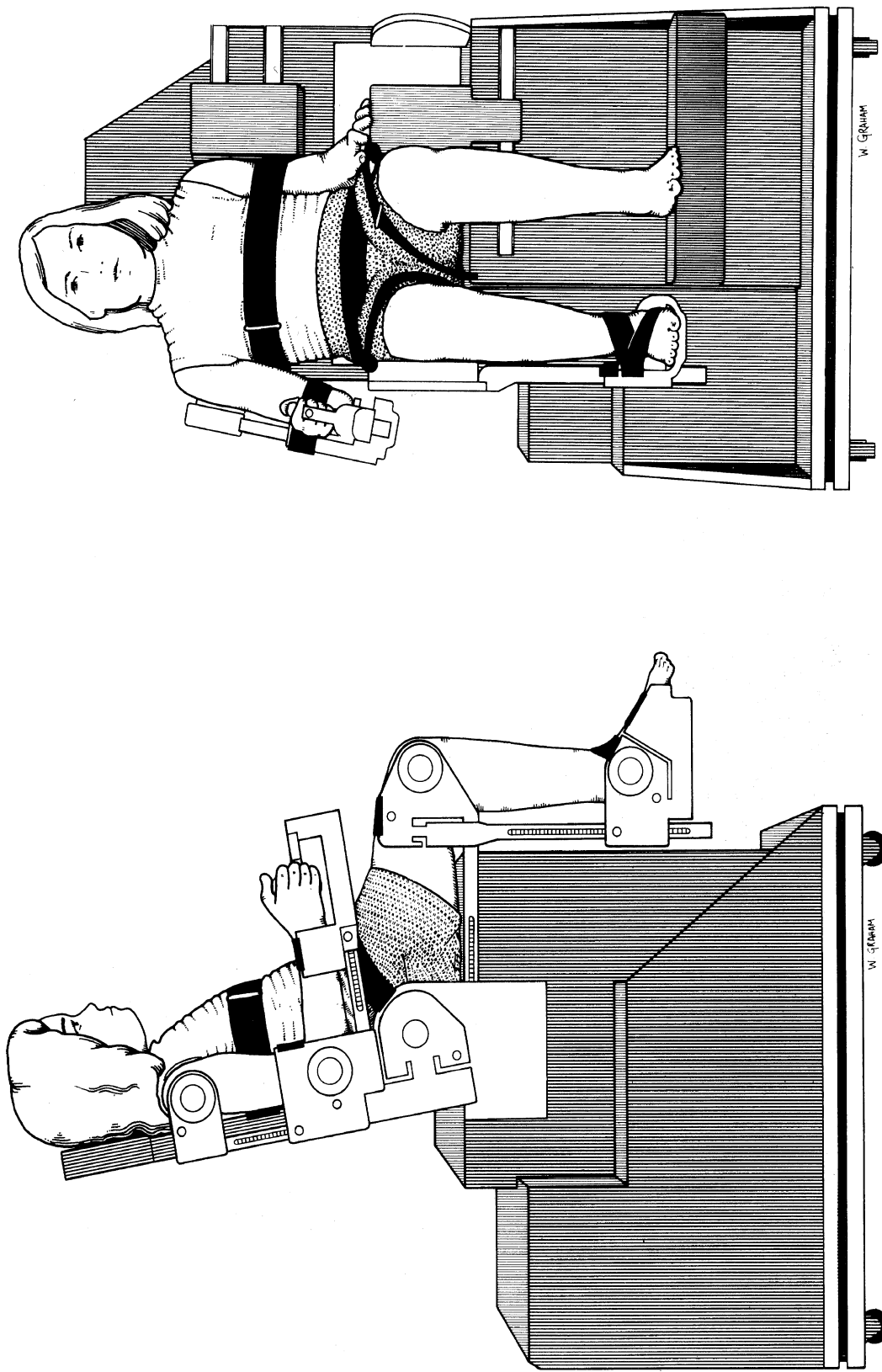


Figure 4 Chair Adjusted For 9 Year Old

Specifically, the upper extremity portion of the chair was used in this study (Figs. 5,6). The upper extremity fixture bends and locks at the elbow and shoulder anatomical joint centers. Adjustable fixture lengths correspond to the radial and humeral lengths. The child climbs into the chair and his wrist and arm are secured to the fixtures with Velcro straps. Another strap is used across the chest to stabilize the child in the chair. The child is allowed to grip a handle mounted at the end of the radial fixture. The elbow joint may be pivoted and locked to any of six possible elbow positions:  $67.5^\circ$ ,  $90^\circ$ ,  $112.5^\circ$ ,  $135^\circ$ ,  $157.5^\circ$ , and  $180^\circ$ . (See Section 3.4, page 214) Moving the fixture with the child's arm secured causes negligible motion between the arm and the arm fixture, since the axis of rotation of the elbow follows closely with that of the arm fixture. Flexing the elbow thus flexes the fixture as well.

Transduction of the elbow torque is accomplished by resistance strain gages mounted on the metal fixture, aligned with the effective elbow axis. The electrical resistance of a strain gage changes in proportion to the mechanical strain of the supporting fixture. For the upper extremity fixture, the mechanical strain measured by the gages, is proportional to the torque about the subject's elbow joint. A change in voltage drop across the strain gages thus corresponds directly to the instantaneous torque about the joint and is fed into the computer for further analysis.

Along with the elbow flexion/extension gages, similiar gages are positioned to measure torque about the wrist and shoulder.

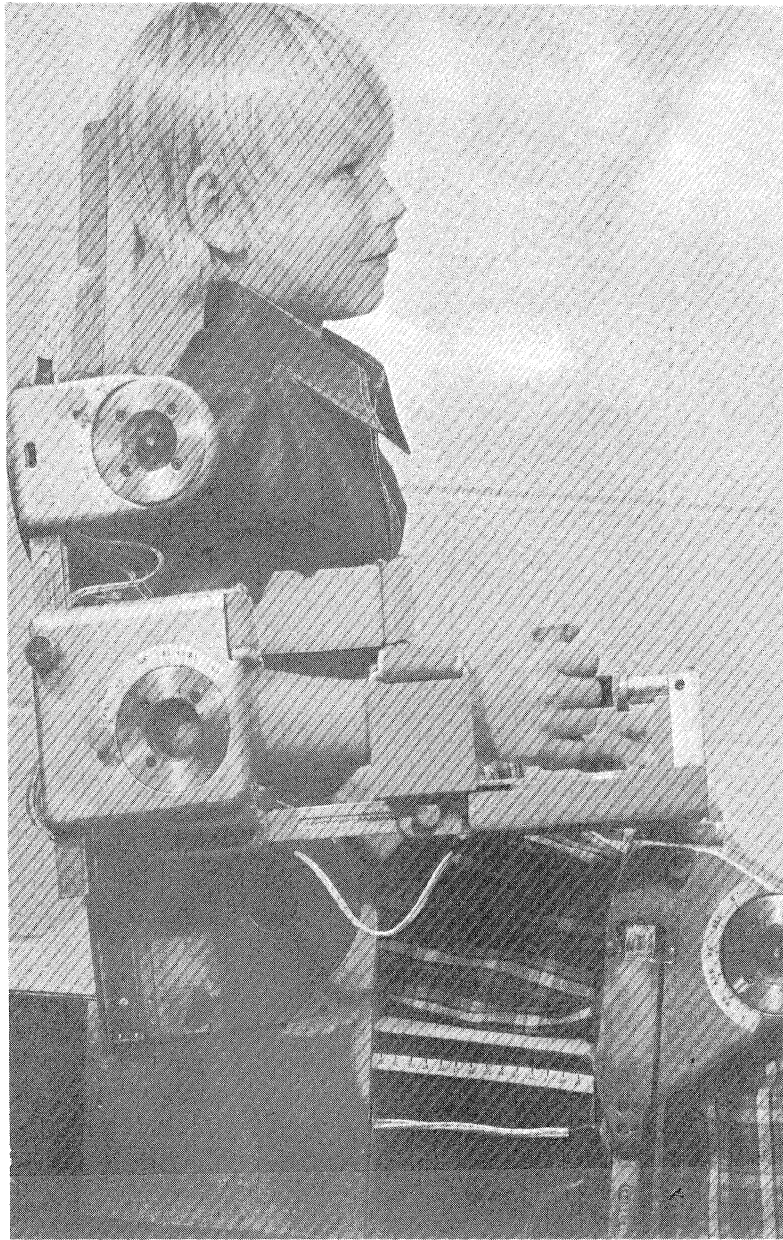


Figure 5 Child in standard test position

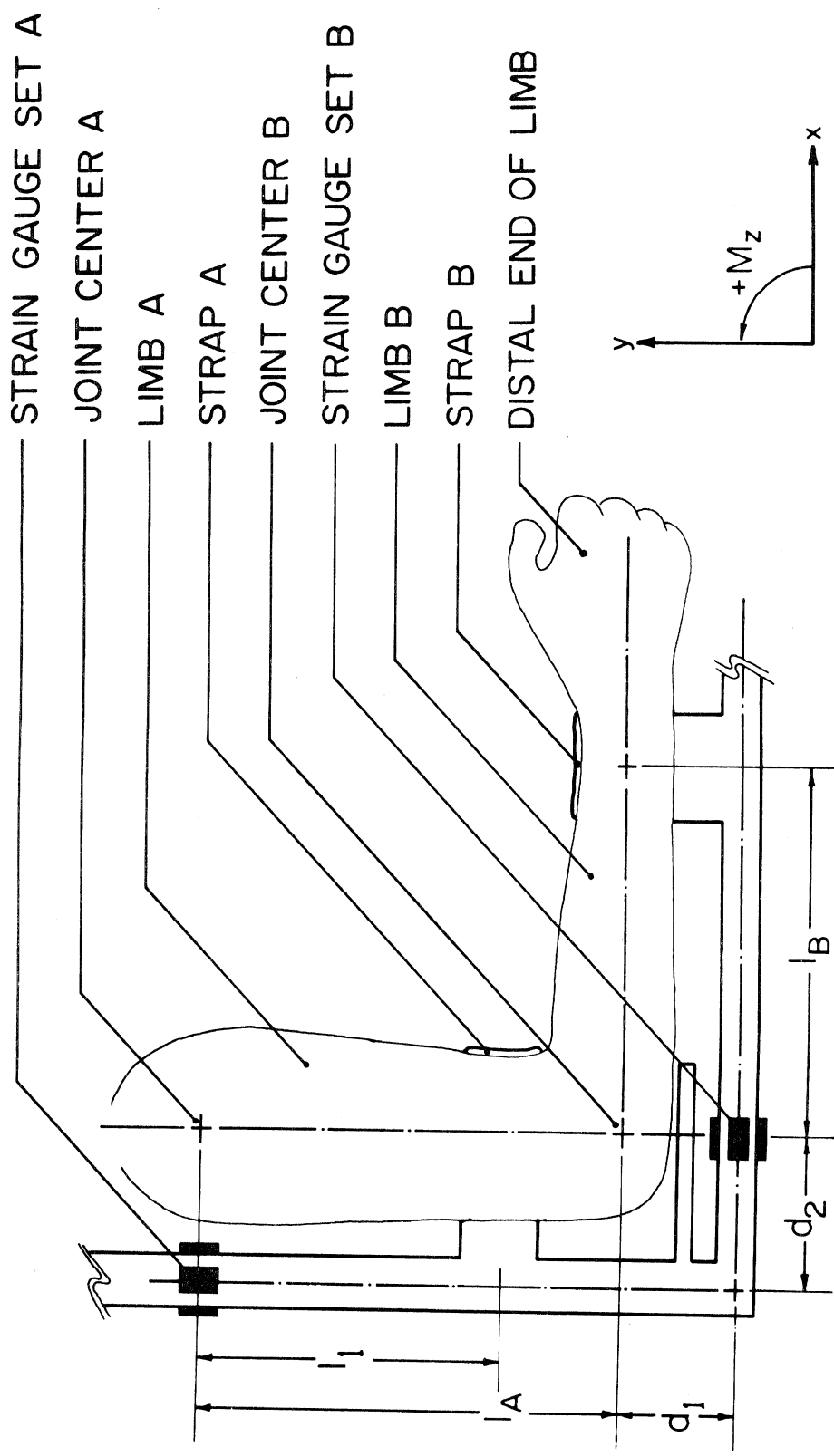


Figure 6 Diagram of Limb and Limb Fixture

Since they are independent measurements, several torques may be recorded simultaneously. In this study, two additional channels were recorded from the arm along with the elbow flexion/extension channel: shoulder flexion/extension and wrist adduction/abduction. These motions occur in the same spatial plane as the elbow flexion/extension. Hip flexion/extension was recorded on an additional channel in order to evaluate reaction forces occurring at this joint. For the elbow tests of this study, the shoulder was always positioned in a 0° flexed position and abducted 5°. The wrist was maintained in a mid pronation-supination position and otherwise anatomically neutral.

### 2.3 Grip Transducer: Design and Function

The grip transducer has several removable parts that serve to adapt the basic transducer mechanism to measure squeeze (Fig. 7) or to measure 3 point pinch and 5 point pinch (Fig. 8). The distance between two parallel rigid surfaces can be adjusted in one centimeter increments so as to mimic the squeezing or pinching of different size objects and to obtain measurements at different positions of hand closure.

Figure nine shows the measurement of 5 point pinch at three different positions. The tips of the fingers are positioned on the transducer. Notice that the lower picture shows a pinch of 9 centimeters. The subject, because of his hand size is unable to pinch a larger dimension.

The operation of the transducer can be described by considering a squeeze strength as shown in Figures 10 and 14. For each



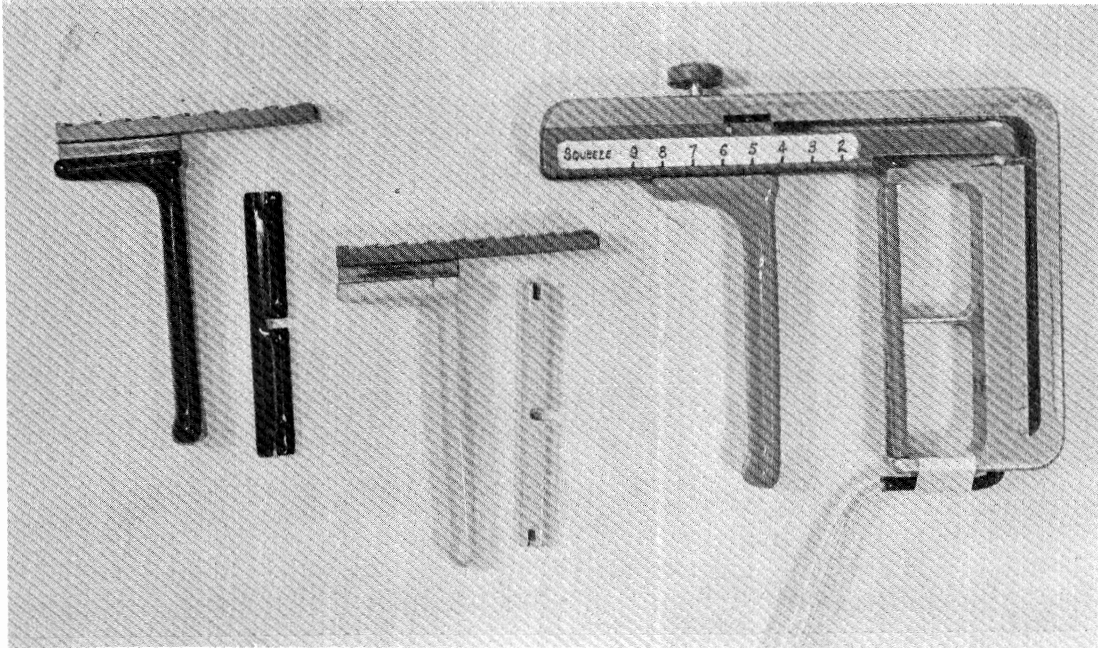


Figure 7 Grip transducer with three handle sets

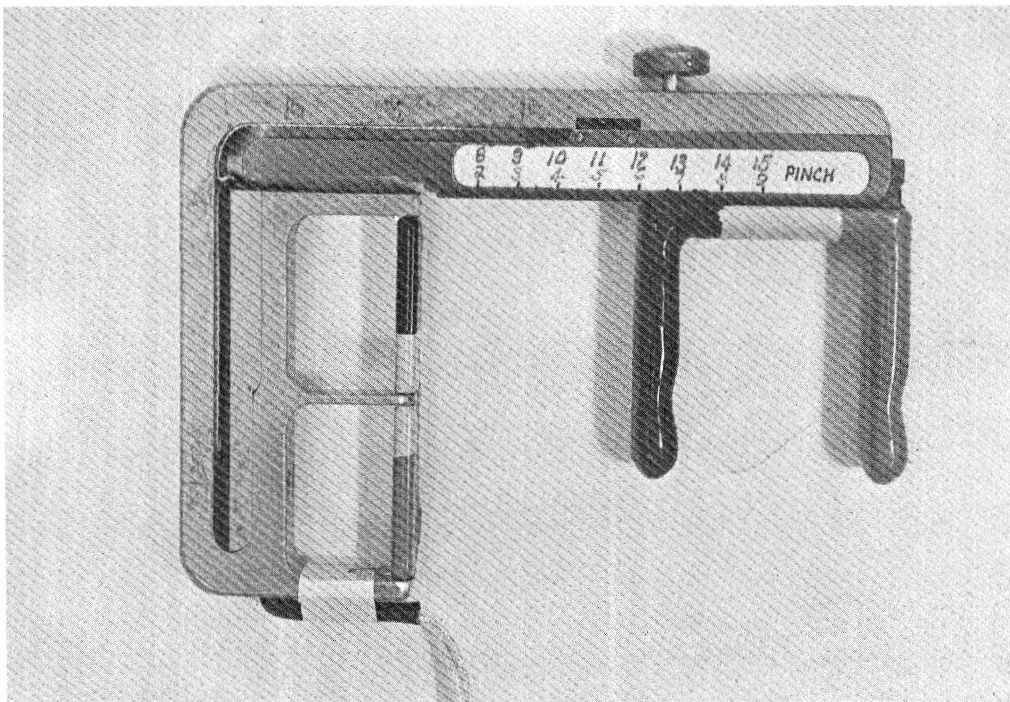


Figure 8 Grip Transducer with pinch handle set

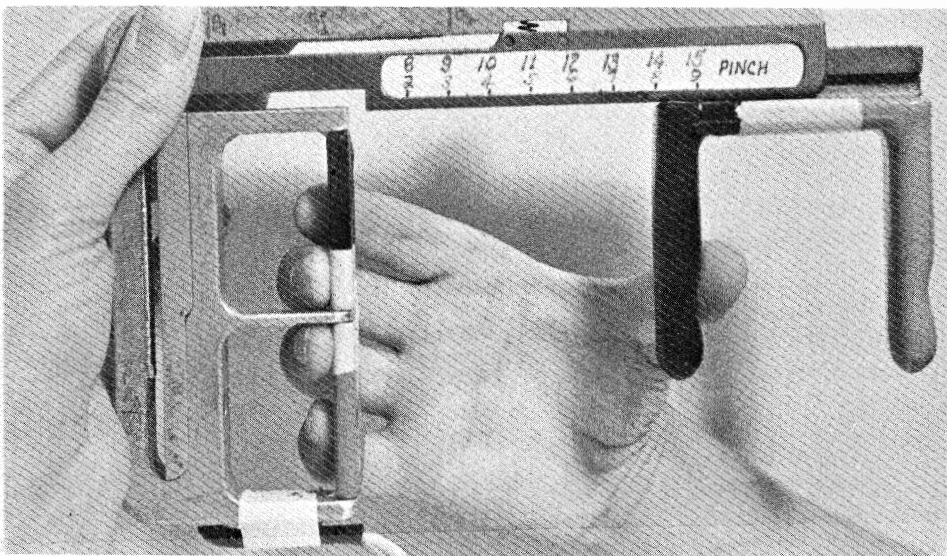
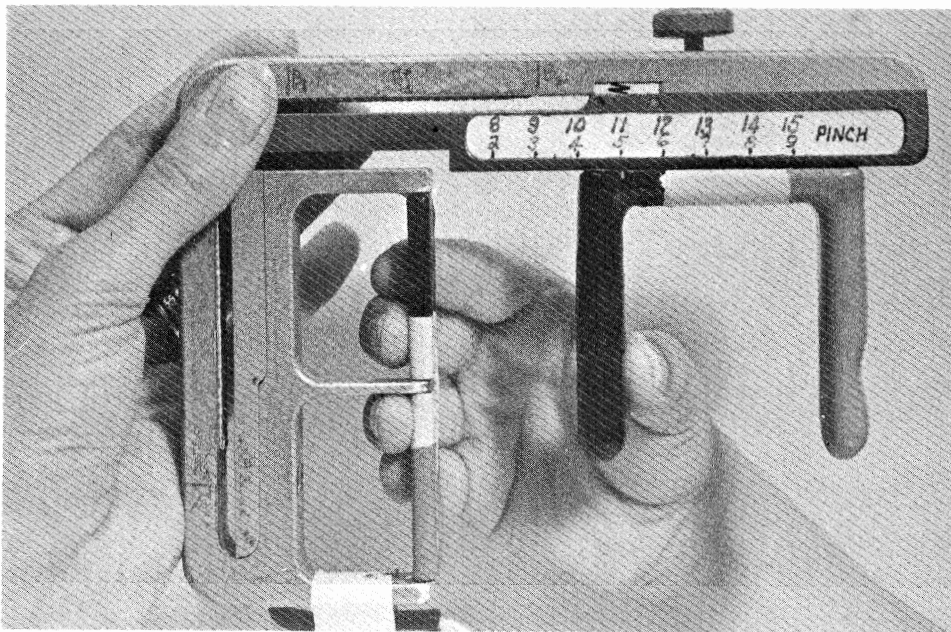
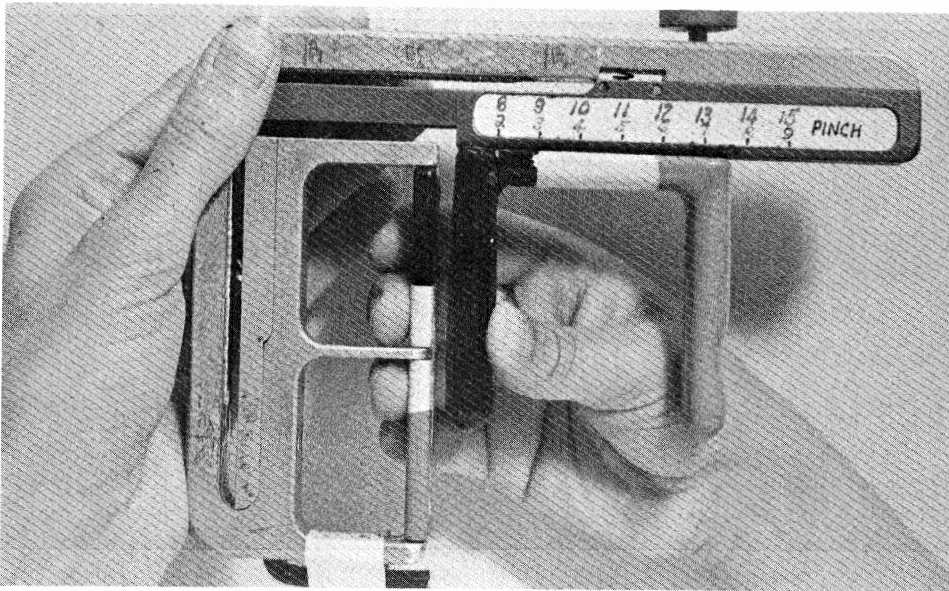


Figure 9 Pinch Transducer at 2, 5, and 9 cm.

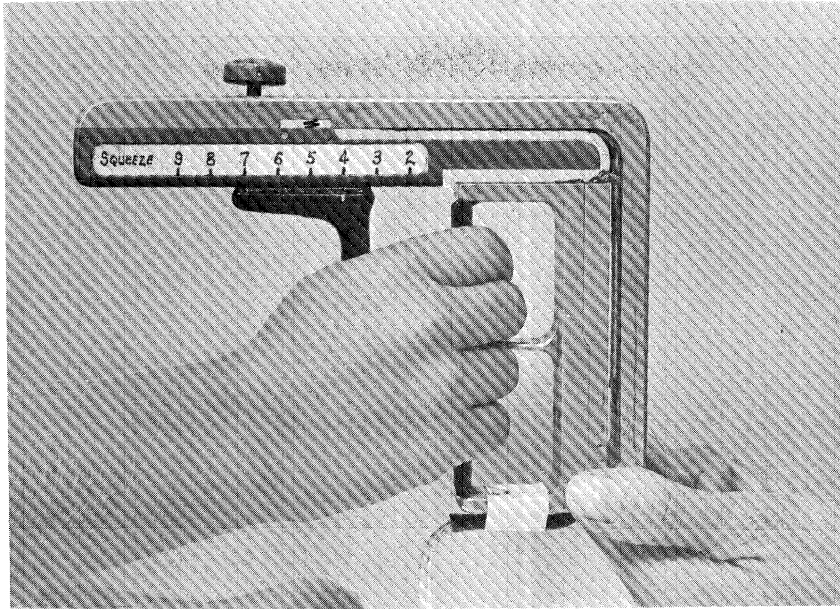


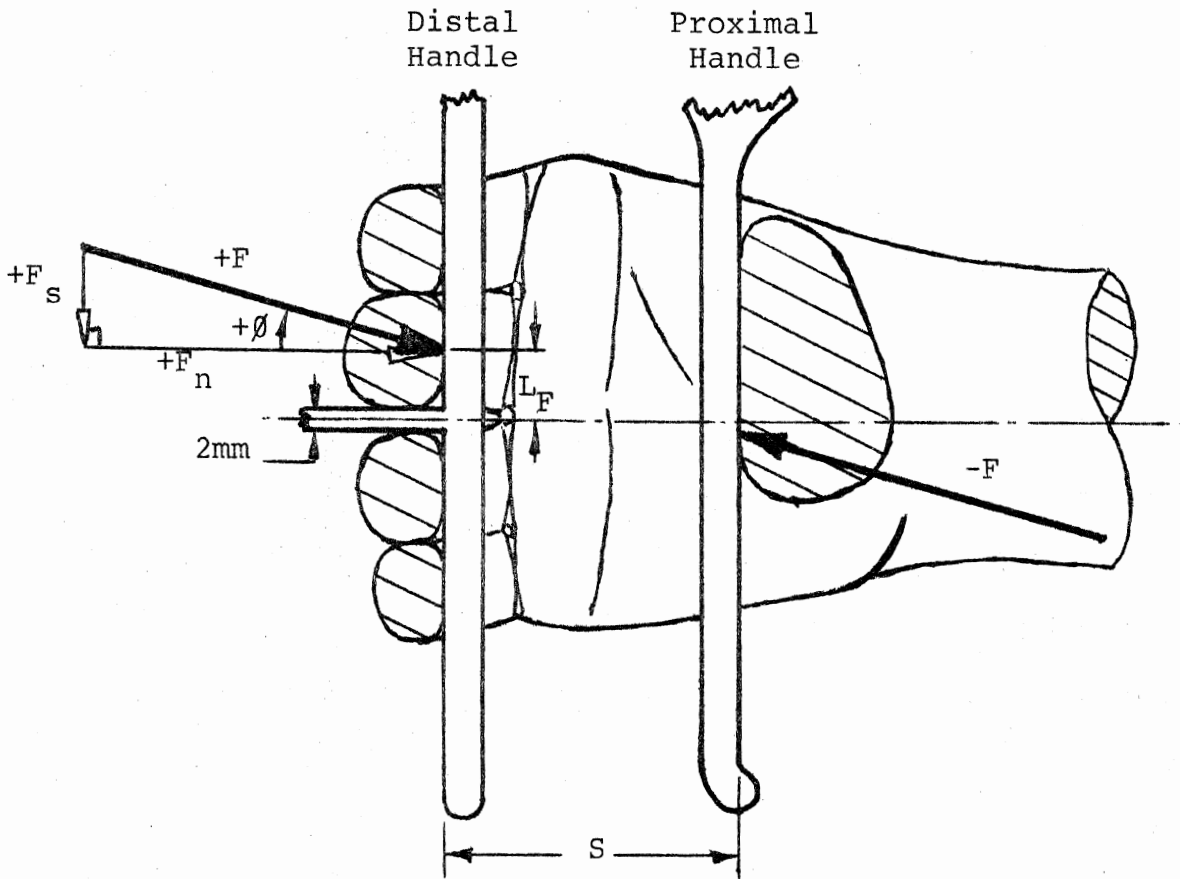
Figure 14 Child performing a squeeze

grip span, the 2-dimensional direction, magnitude, and location of the resultant force exerted by the hand on the handle is measured and recorded. This resultant force lies in the geometric plane formed by the two parallel handle halves. The component normal or perpendicular to the handle surfaces ( $F_n$ ) has been classically measured in previous studies and is the greatest in magnitude. A second component, a shear force, which is parallel to the handle surfaces ( $F_s$ ) was also measured by the transducer to:

- 1) determine the shear effect of the hand on the handle during a squeezing or pinching exertion,
- 2) better identify the ultimate 3-dimensional character of forces generated in gripping, and
- 3) study the variation of force direction throughout the course of a five second exertion and from subject to subject.

Diagrams of the two force components for 3 point pinch and pinch are given in Figures 11 and 12.

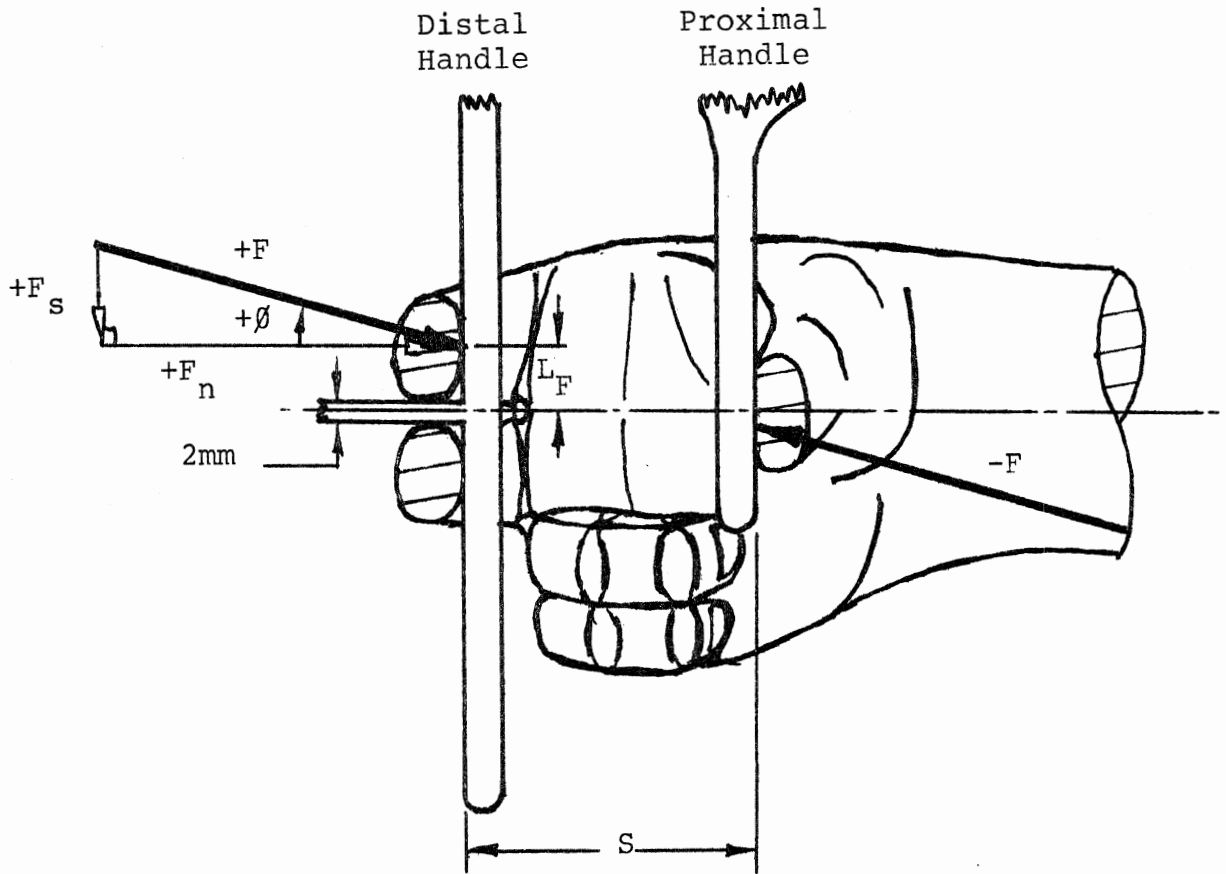
GRIP: SQUEEZE  
FORCE DIAGRAM



- $F$  = Total resultant squeeze force
- $F_n$  = Normal component of squeeze force (perpendicular to handle surface)
- $F_s$  = Shear component of squeeze force
- $L_F$  = Position (vector) of resultant force on distal handle surface (measured from centerline between second and third finger)
- $\theta$  = Angle of resultant force ( $F$ ) with respect to handle centerline
- $S$  = Handle span

Figure 10

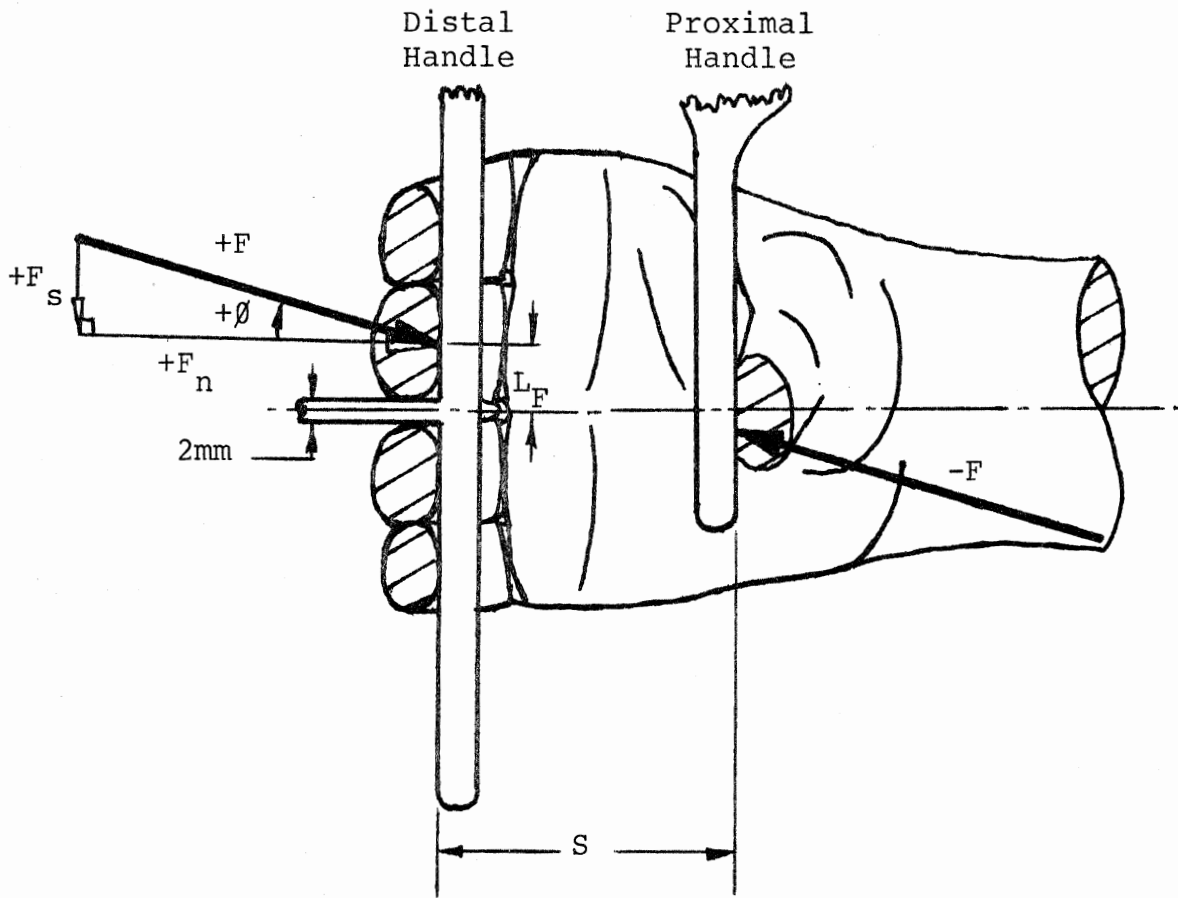
GRIP: 3 POINT PINCH  
FORCE DIAGRAM



- $F$  = Total resultant squeeze force
- $F_n$  = Normal component of squeeze force (perpendicular to handle surface)
- $F_s$  = Shear component of squeeze force
- $L_F$  = Position (vector) of resultant force on distal handle surface (measured from centerline between second and third finger)
- $\phi$  = Angle of resultant force ( $F$ ) with respect to handle centerline
- $S$  = Handle span

Figure 11

GRIP: 5 POINT PINCH  
FORCE DIAGRAM



- $F$  = Total resultant squeeze force
- $F_n$  = Normal component of squeeze force (perpendicular to handle surface)
- $F_s$  = Shear component of squeeze force
- $L_F$  = Position (vector) of resultant force on distal handle surface (measured from centerline between second and third finger)
- $\phi$  = Angle of resultant force ( $F$ ) with respect to handle centerline
- $S$  = Handle span

Figure 12

The third force component, that perpendicular to the plane of the handle, was not measured. Its magnitude is felt to be much smaller than the normal and shear components and an insignificant factor in determining significant gripping characteristics.

The location (LF) of the resultant force in the plane of the handle was measured relative to a thin center brace (Fig. 10). This brace serves as a centerline of the transducer and thus the zero reference point for measuring LF. During gripping or pinching the hand is positioned so that as many fingers are on one side of the centerline as on the other side. The distance (LF) when compared with the anthropometric measurement of finger breadth gives the resultant force position on a finger surface. Also, with the handle span and force angle known, the resultant force position may be determined on the proximal handle surface.

The basic transducer consists of a thin U-shaped aluminum bar onto which two handle halves may be mounted, one stationary and one adjustable at 1 cm. intervals of grip span. On the inner surface of the bar frame, five sets of resistance strain gages are mounted. The electrical output of the gages is fed into the computer and processed in a manner similar to the elbow strain gage signals. Three electrical channels of output from these gages uniquely determine two components of the resultant force and its location. See the appendix for a description of the principles of the grip strength transducer.

Four different pairs of handles are used on the transducer and are described in Table A (Fig. 13). All handles are color-

TABLE A

TEST	FINGER LENGTH	HANDLE GEOMETRY	HANDLE SPAN (1 cm increments)	MAXIMUM SPAN TESTED
Squeeze	L < 5	Small Radius (5 mm)	2.0 - 6.0 cm	1.1 L (cm)
Squeeze	5 < L < 6	Medium Radius (7 mm)	2.0 - 7.0 cm	1.1 L (cm)
Squeeze	L > 6	Large Radius (9 mm)	2.0 - 9.0 cm	1.1 L (cm)
3 pt/5 pt Pinch	All	Flat	2.0 - 15.0 cm	1.5 L (cm)

REMARKS:

1. Middle finger measurement (L) is taken from tip of the second finger to its palmar skinfold.
2. Handle radii chosen to fit average length of middle phalange of the second finger for each hand size category.
3. Maximum span tested is limited to:  
Pinch span = 1.5 L  
Squeeze span = 1.1 L

Figure 13 Selection guide for handle sets



coded and coated with 2 mm thick hard rubber to distribute hand pressure. One pair is used for all hand sizes in measuring 3 and 5 point pinch (Fig. 8) while the other three pairs are used for small, medium, and large hand sizes in squeeze tests (Fig. 7). The possible span range for pinch tests is 2-15 cm. and for squeeze tests is 2-9 cm. All spans are adjustable in 1 cm. increments with a minimum spacing of 2 cm. Where necessary, the maximum span actually tested on a given child was limited to 1.5 times the middle finger length (MP joint to tip, phalanx III) in the pinch tests and 1.1 times the middle finger length in the squeeze tests. These limits were empirically determined to define the maximum span at which a child could form a practical grip on the handles. Radii on the three squeeze handle sets were also empirically derived to provide an average child, of a specified hand size range, the greatest possible handle surface area over which to distribute gripping pressure. Such a broad smooth grip surface prevents the limitation of exertion due to the pain of gripping too small an object. Handle widths were limited to 2 times the radius to accommodate full flexion of the fingers in the 2 cm. span.

Positioning of the hand is controlled vertically along the distal handle by the inter-finger center brace separating two or four fingers used in the tests. Transverse positioning during pinch tests is restricted to only distal phalange contact at the handles. In the squeeze or power grip, the distal handle contact is restricted to the middle phalange of the fingers.

Placement of the thenar eminence vertically along the proximal handle is allowed to vary to suit the subject's comfort. Proximal handle contact extends from the hypothenar eminence to the finger web between the thumb and first finger. Flexion of the metacarpal and interphalangeal joint positions in all test positions is allowed to vary.

Measurement of normal and shear forces,  $F_n$  and  $F_s$ , respectively, are accurate within .1 Kgf. Each component is measured independently. Determination of the location of the resultant force is accurate within  $\pm$  .8 mm. for forces on the handle regions used to determine the force location from the three channels of information, the measurement error for force location tends to approximately double when either the normal force component ( $F_n$ ) falls below 0.1 Kgf or the ratio  $\frac{F_n}{F_s} \ll 1$ . In the application of the instrument for pinch and squeeze measurements, however, these extremes are either not encountered ( $\frac{F_n}{F_s} > 25$  usually) or not used for maximum strength determinations ( $F_n > 1$  Kgf usually).

## 2.4 Anthropometer: Design and Function

An automated anthropometer was constructed to minimize the possibility of anthropometric linkage measurement error and recording error and to increase the efficiency of the measuring process. A conventional anthropometer was modified by the addition of a switch, potentiometers, and spring-cable assembly. As shown in Figures 15 and 16, the potentiometer was mounted on the end of the caliper and protected by a box. A double pulley locked onto its shaft was fastened both to a cable-spring recoil mechanism lying within the anthropometer shaft, and to the sliding blade of the caliper external to its shaft. The potentiometer was wired to the computer through the switch mounted on the potentiometer box.

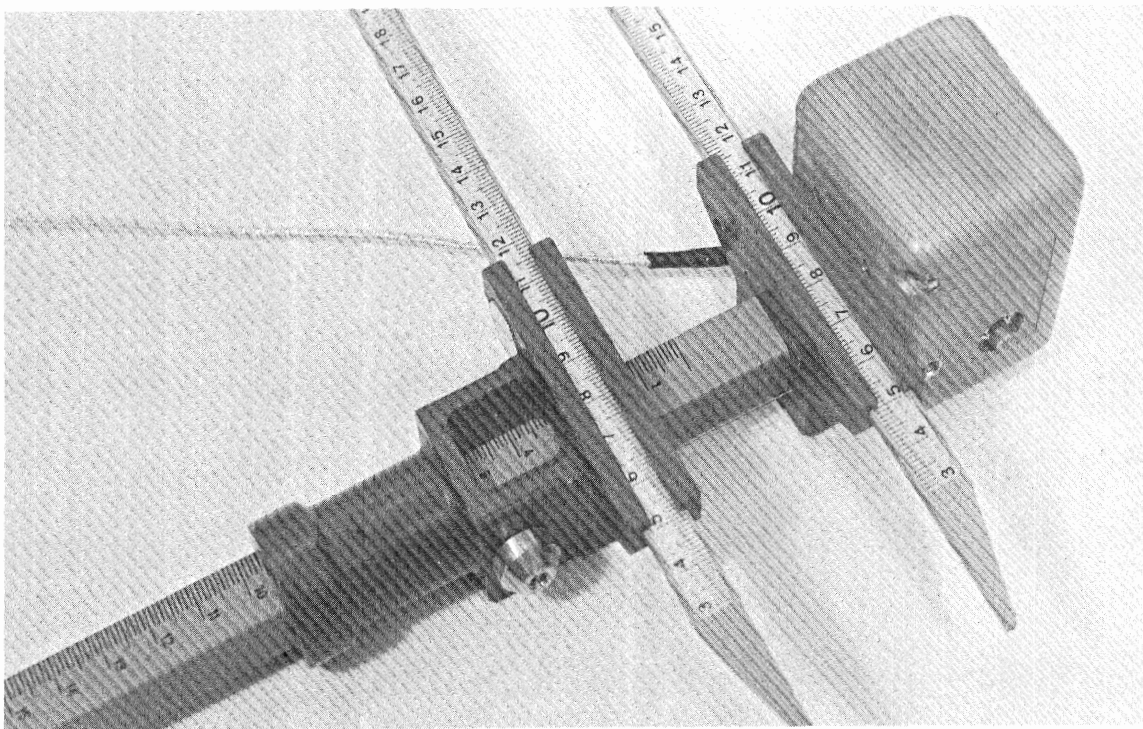


Figure 15 Automated anthropometer

Sliding the caliper blade to a linkage dimension thus rotates the potentiometer proportionally, while the spring maintains proper cable tension. Depressing the switch allows the computer to record the voltage output of the potentiometer in proportion to the anthropometric opening.

For measurements under 30 cm. the anthropometer is accurate to  $\pm 1$  mm. Adding anthropometer shaft extensions allows measurements up to 120 cm., accurate to  $\pm 3$  mm.

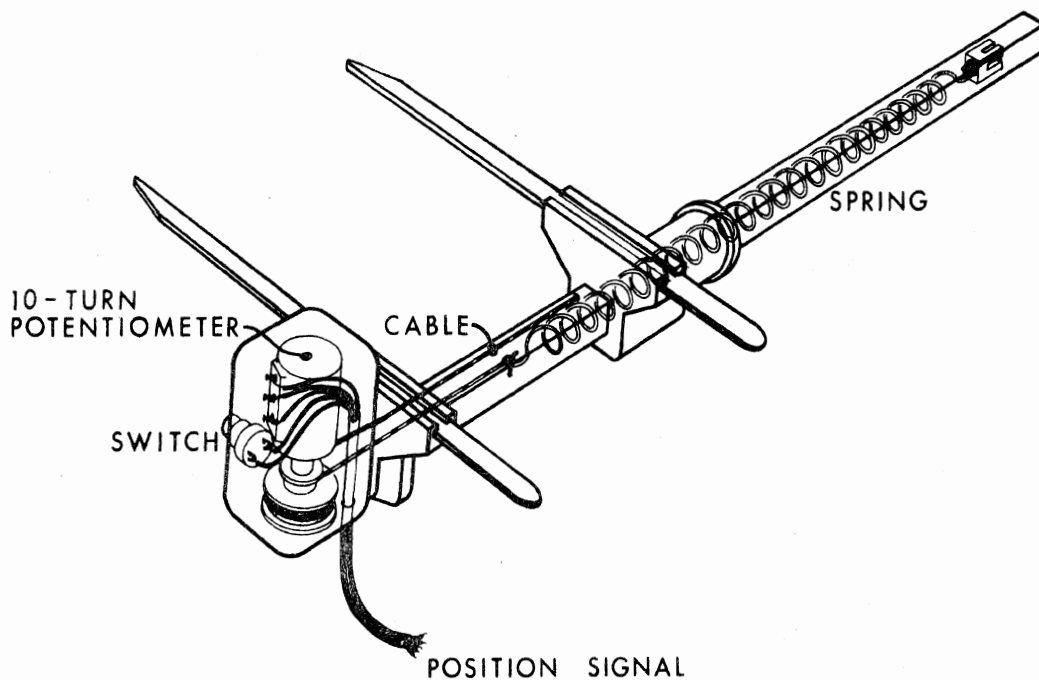


Figure 16 Automated Anthropometer  
(internal construction)

## 2.5 Strength Criteria

Human strength researchers have been in considerable disagreement as to the best measurement of strength. Assessment of strength must occur over a long enough period of time to eliminate effects due to "explosive" strength and yet must be over a short enough duration to eliminate decreases in strength due to fatigue.

A variety of algorithms were investigated in the previous study (162). The average torque (or force) generated over a period of one second was chosen to represent strength. This duration is long enough to minimize the effect of a single erroneously high value produced by dynamic inertial effects but short enough to minimize the effect of fatigue and loss of motivation.

In this report, when a single number is assigned to "strength", it is obtained by selecting the average value over one second of contiguous data that has the greatest value of all possible contiguous one second intervals in the five second exertion. This algorithm has been implemented in the computer programs, and has the advantage of not requiring human judgement and intervention for its proper operation. Thus "strength" is represented by an average over one second or 20 data points.

## 2.6 Calibration of Equipment

Calibration of the elbow transducer was accomplished using a method devised to simultaneously calibrate all the upper extremity transducers of the strength chair. The arm of the chair

was abducted 45° and flexed 22.5° with the elbow in a 90° position (Fig. 17) while locked in the position, a weight of 4.47 Kg. was suspended at a standard location on the hand fixture, providing known components of torque to all gages of the extremity. A computer program automatically sampled the output from each gage set in this loaded configuration and after the weight was removed, the channels were again sampled to obtain baseline readings. Finally, the difference in the gage outputs was expressed as a calibration factor.

$$\text{Calibration factor} = \frac{V \text{ load} - V \text{ no load}}{\text{input torque}}$$

All instruments in a data acquisition channel are thus calibrated in a single step. Periodically during the study, the calibration of the system was verified.

The grip transducer was calibrated similarly with a weight suspended from the transducer handle to provide known force components perpendicular and parallel to the handle surface. The fixed position of the weight also provided information to calculate a calibration factor for a force.

Anthropometer calibration was easily accomplished by first obtaining a zero (closed) reading and then moving to a predetermined measurement (read from the scale on its shaft) for a second reading. The difference in voltage readings divided by the caliper span was used as a calibration factor for the instrument.

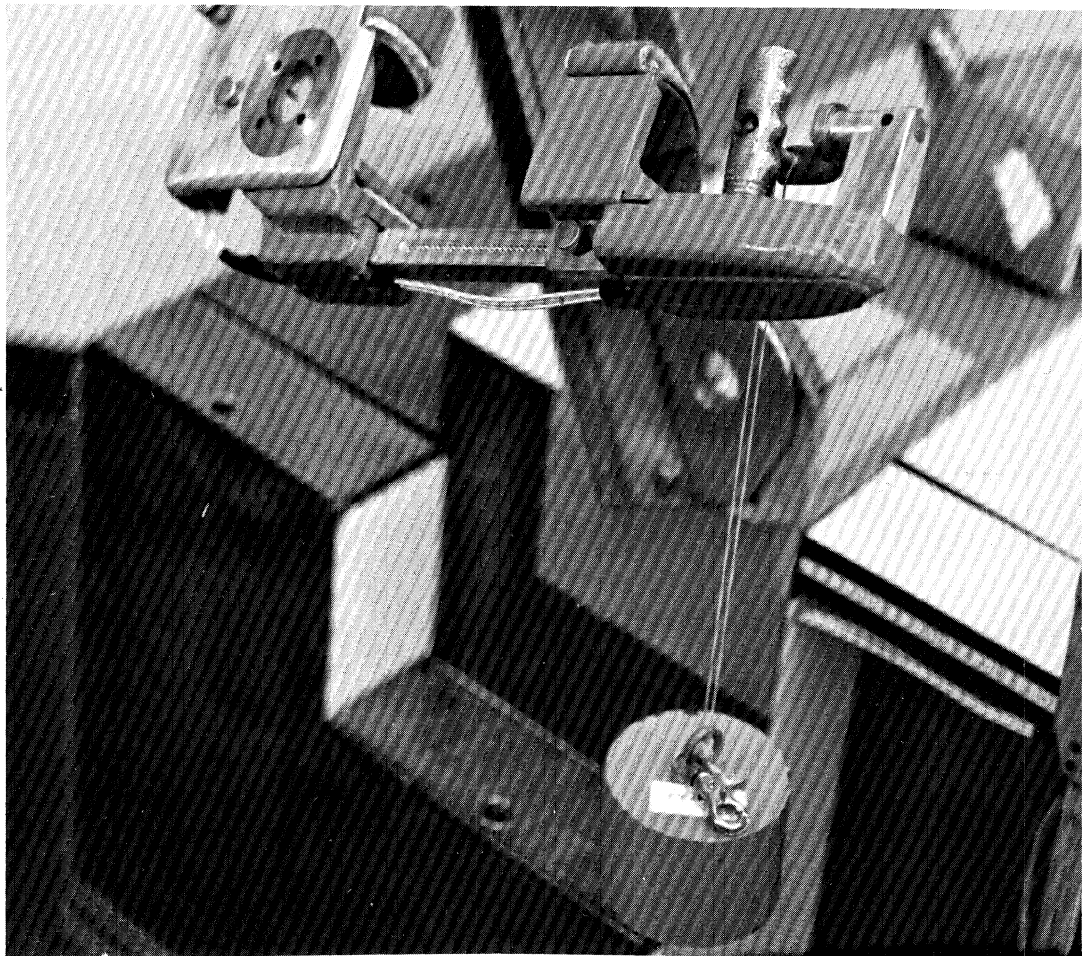
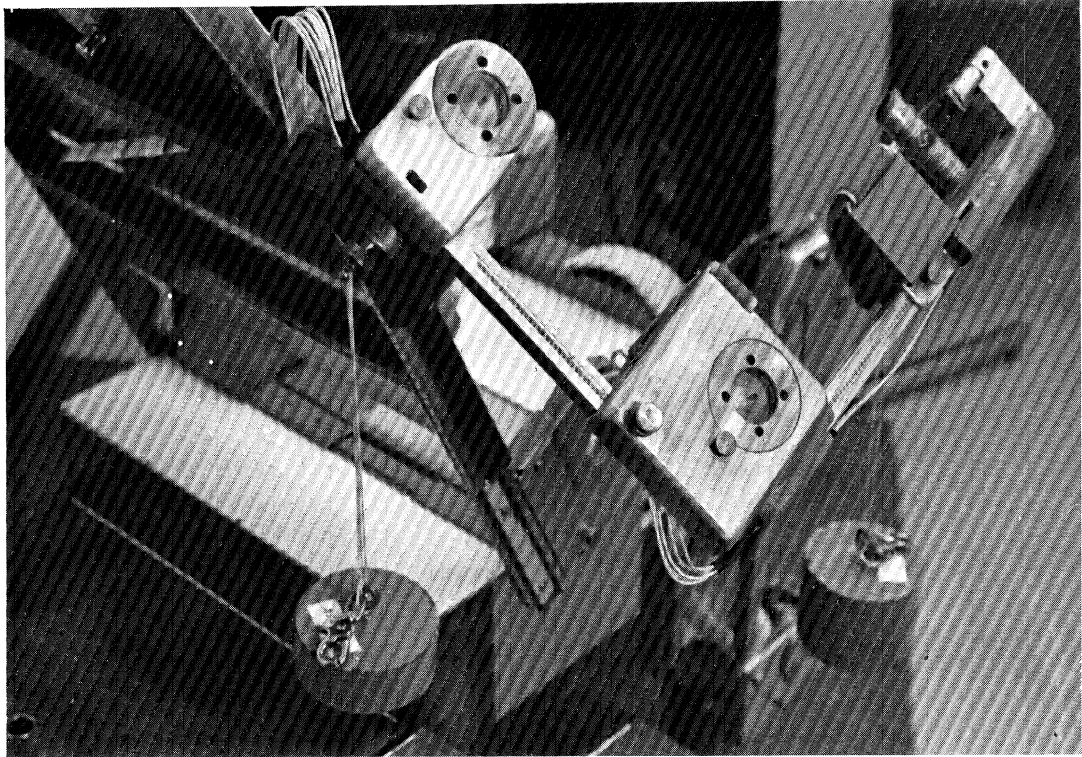


Figure 17 Attachment of Calibration Weights

## 2.7 Data Acquisition and Display

The data acquisition system used for this project consisted of a 16 bit Data General Nova 1220 computer with 16K words of memory, a 24 channel analog to digital converter, a dual Linc tape magnetic tape system, and a Tektronix 4010 graphics terminal. Twenty-four instrumentation amplifiers, with adjustable gain were used to amplify the strain gage signals to a value of  $\pm 5$  volts for the 12 bit analog to digital converter. This system allows a signal resolution of 1 part in 4096.

The data acquisition programs were written in an expanded version of the Basic (R) language. The programs control the acquisition of descriptive information such as age, name, birth-date, as well as the sequencing of anthropometric and strength measurements (approximately 63 measurements).

## 2.8 Testing Procedure

All testing in the Strength Study was done at the Child Strength Laboratory at C.S. Mott Children's Hospital. Children were tested during a six month period. Parents were contacted by phone and appointments set up convenient for the child and parent. The children ranged in age between 2 1/2 years and 10 1/2 years. The younger children were usually tested during the morning and early afternoon hours of the day, while the older children came in



after school. Race and sex were carefully considered in the recruiting, in order that the sample be a fair representation of the population.

Each testing session, including the anthropometric measurements, described in section 3.2, lasted about 30 to 40 minutes. Each child was tested in a single session, with the exception of those children who performed both the elbow and the grip tests.

Parents were required to sign a consent form which gave permission for the child to be tested (Fig. 19) and to fill out a questionnaire containing general information, such as the child's date of birth, address, etc. (Fig. 18). Parents were encouraged to remain in the lab for the testing session, and most did so. Many of the children who participated in the study came with a sibling or a friend. A small play area was used in one part of the lab, where one or more children could play while another was being tested. During this wait, the child could draw a picture, which was later put on the wall of the lab. This decoration on the walls helped make a friendly environment for the children.

First, linkage measurements were obtained and standing height and weight were measured with the child's shoes removed. An automatic anthropometer was used to enter the measurements directly into the computer. The body weight was obtained with the child seated on the back of the strength chair. When all linkage measurements had been obtained, the results were displayed on the graphics terminal for evaluation.

Using the linkage measurements, the chair was adjusted according to the child's size. In this way each child could sit comfortably in the chair during the testing session. A "zero weight" was then taken before the session began. This was done by the computer measuring the initial voltage produced on each of the strain gages of the empty chair. Then the child was seated in the strength chair and the Velcro<sup>(R)</sup> straps were carefully placed over the necessary limbs as a means of maintaining a known position during each test. The child was encouraged to fasten some of the straps himself to relieve any apprehensions which he might have.

Simple instructions, which explained the test procedure, were given each child before the testing session. Then, before each of the tests specific directions and a demonstration helped the child understand exactly how to perform the test. The child was asked to sustain each movement as hard as he could for a time interval of five seconds. At the end of this time an audible tone, generated by the computer program, signaled the end of the test. Immediately after each test, a graph of the torque-force vs. time was displayed on the computer terminal. This "picture" allowed the child to see the results of his strength after each of the tests. The tester could decide whether to accept, delete, or repeat the test, depending on the child's performance. If a significant amount of time elapsed in which there was little or no exertion by the child, or if the directions were not followed properly, then the test was deleted and repeated. Later in the sequence the omitted tests were performed. Because of the repetition in using

certain muscle groups of the arm and hand, the child was given adequate rest between each test. If there was any doubt of the child being able to perform the test properly, it was omitted and the next test done. Thus each test was hoped to be an accurate display of the child's strength.

Following the test session, the child was given a snack. Parents and children were very cooperative during the study and there were very few times when the tester did not receive the desirable results.

Motivational techniques for this study remained much the same as those used in the previous study (162). Children were tested on a volunteer basis and no child was tested that didn't want to be. Important in the testing session was the interaction between the child and the tester. The tester was a certified elementary school teacher with extensive experience with children and parents. Her techniques with the children helped determine the outcome of the session, which was to obtain the best possible results from each child during each test.

Verbal encouragement during the actual test worked as the most important motivational technique. The graphics display on the computer terminal, which allowed the child to view the results immediately after each test, was also an important factor in motivation. The child could see his "picture" of his strength right after each test. This instant "feedback" gave the child the incentive to perform his best each time.

To compensate for parking and travel costs, all the children, or their parents, received reimbursement of \$5.00 per visit. To some of the children this fee served as a type of motivation.

CHILD STRENGTH STUDY  
University of Michigan Department of Pediatrics  
Ann Arbor, Michigan 48104

Name of School \_\_\_\_\_ Name of Teacher \_\_\_\_\_

Child's Name \_\_\_\_\_

Address \_\_\_\_\_

Child's Date of Birth \_\_\_\_\_ Male

Female

Child's Race \_\_\_\_\_

Mother's Occupation \_\_\_\_\_

Father's Occupation \_\_\_\_\_

How long have you lived in this community? \_\_\_\_\_

Mother's Race: Black  Oriental  White

Other  Please specify \_\_\_\_\_

Father's Race: Black  Oriental  White

Other  Please specify \_\_\_\_\_

Father's Education: 8 years or under  9-12 yrs.  More than 12 yrs.

Completed College (16 yrs.)  More than 16 yrs.

Mother's Education: 8 years or under  9-12 yrs.  More than 12 yrs.

Completed College  More than 16 yrs.

Number of brothers \_\_\_\_\_ Number of sisters \_\_\_\_\_

What is the birth order of this child in relation to brothers and sisters? \_\_\_\_\_

For example: 1 - oldest, 2 - second oldest, etc.

Has this child been under treatment for any serious illness? \_\_\_\_\_

If so, please explain \_\_\_\_\_

CHILD STRENGTH STUDY

Consent Form

I, the undersigned, understand that the purpose of this study is to take some strength measurements of my child. I am aware that these measurements will enable collection of information about the physical strength of children at different age levels and use of this information in constructing guidelines for the safer design of children's products.

I have been informed that there will be no health hazards or discomfort to my child associated with this, and that participation is voluntary. In order to take measurements with accuracy, it is necessary for the child to remove shoes only.

I further understand that all of the data is confidential and I agree to allow publication of any or all of the data collected on my child if presented in a coded form.

---

Child's Name

---

Signature of Parent

## 2.9 Data Reduction and Analysis

Description of the data acquisition program has already been presented (Sec. 2.7). This program was used to generate 84 magnetic tapes filled with data files on each subject tested. Each file represents a permanent "time" record of a subject's tests, making it possible to analyze the data via any method desired.

For quantitative and statistical analysis of the data, a series of processing and reducing programs was written and utilized. The first reduction program condensed each data file into a more compact and analyzable form, coding the subject's background information and replacing the 400 data points for each test with four calculated strength values, based on the one-second-moving-point-average technique (Sec. 2.5). Reduced files were then transmitted to the University of Michigan's AMDAHL 470 computer for further processing and statistical analysis.

Ages were computed by subtracting the birthdate from the date of the subject's most recent testing session. Ages were represented internally in days and were computed using the approximation of 365 days to the year and 30 days to the month. Ages computed in this fashion are never more than seven days in error, which was sufficient resolution for the purposes of this study.

Data was then analyzed statistically using the Michigan Interactive Data Analysis System (MIDAS), a comprehensive set of statistical analysis programs developed by the Statistical Research Laboratory of the University of Michigan. For the purpose of

analysis, subjects were grouped into 8 yearly age groups, from 3 to 10 years. Ages were rounded to the nearest whole year so that altogether an age range of 2.5 to 10.5 years was represented. Each of the strength and linkage measurements were analyzed by age for the following quantities: number of subjects (N), mean ( $\bar{X}$ ), Standard Deviation ( $S_x$ ), median, 5th or 15th percentile, minimum value, and maximum value. (Body weight was included here as a linkage measurement.) The exact percentile reported was dependent on sample size. Where (N) was small ( $\leq 20$ ) 15th and 85th percentiles were more meaningful. Both sexes were combined to insure sufficient sample size for statistical analysis. The results of these analyses are reported in tabular form at the end of each data section.

Graphical presentation of the data use scatter plots for an exact representation of the data and to avoid any bias which might be introduced by curve fitting. The amount of grouping is readily apparent along with the actual sample size. The scales have been expanded to provide the best resolution of points. Note that sample size decreases for large grip spans, reflecting the limited grip spans capability of small hands. All graphs of strength vs body size include a first order regression line drawn through the scatter plot to indicate the trend. Graphs of strength vs position show the means for pooled age groups plotted and connected via straight lines.

### 3.0 RESULTS

#### 3.1 Description of Data Presentation

The following sections present a summary of the data, with both sexes combined, for the 33 linkage measurements, 3 hand strength tests at different spans, and elbow flexion/extension strength tests at different joint positions. Information on the interpretation of the strength data is contained in the next section. The data section is arranged in modules corresponding to a general test or measurement. Each module consists of: 1) A description of the test, the anthropometric measurements taken, adjustment of the equipment, and instructions to the subject, 2) A photograph of the subject performing the test, and in many cases, a drawing which illustrates the movement is included for clarity, 3) A statistical tabulation of the data including the sample size (N), the mean ( $\bar{X}$ ), the standard deviation ( $S_x$ ), the minimum, 5th or 15th percentile, median, 85th or 95th percentile, and maximum values, tabulated by one year intervals, 4) Scatter plot of the data. Items 3 and 4 are then sequentially repeated for the same test in a different test position (span, angle).

The data are presented for linkage measurements in a similar format. The thirty three two-page modules contain a definition of how the measurement was taken along with a photograph or illustration of the measurement. A statistical summary of the data for one year age intervals together with a graphical presentation of the data are given for combined sexes.



### 3.1.1 Interpretation of Strength Data

3.1.1.1 Physical Relationships and Units: In the following tables and graphs, the strength data are presented in the torque units of kilogram force-centimeter or force units of kilogram force (squeeze and pinch tests). Kiloponds (Kp) or kilogram force (Kgf) is defined to be the magnitude of force required to accelerate a mass of 1 kilogram at 1 g (acceleration due to gravity). A kilogram force-centimeter (Kgf-cm) is defined to be the magnitude of torque generated about an axis of rotation due to the action of a force of 1 kilogram force occurring 1 centimeter away at right angles to the axis. These two general relationships may be summarized along with metric units used in the study as follows:

#### FORCE

From Newton's Second Law      Where:

$$F = (m) (a)$$

F = force (Newtons)

m = mass (Kg)

a = acceleration ( $M/sec^2$ )

or, in terms of Kiloponds:

$$F = (1/g) (m) (a)$$

F = force (Kp or Kgf)

m = mass (Kg)

a = acceleration ( $M/sec^2$ )

g = acceleration due to gravity  
at the Earth's surface  
= ( $9.80 M/sec^2$ )

#### TORQUE

$$T = (F) (D)$$

T = torque in (Kgf-cm)

F = force in (Kgf)

D = perpendicular distance from  
force to axis of rotation (cm)

## UNITS

The elbow strength data is presented in the torque unit of kilogram force-centimeters (Kgf-cm). It is worthwhile to note that these are identical units to kilopond-centimeters (Kp-cm) since 1 Kgf = 1 Kp. The following conversions may prove useful:

$$\begin{aligned} 1 \text{ Kgf-cm} &= 1 \text{ Kp-cm} \\ &= 9.806 \text{ N-cm} = 0.09806 \text{ N-M} \end{aligned}$$

$$1 \text{ Kgf-cm} = 0.806 \text{ in-lbf}$$

Notice 1 Kgf-cm is only slightly less than 1 in-lbf which is useful for estimating data in English units.

Units for the grip strength data are in Kiloqram force (Kqf). Conversion to Newtons or pound force is thus:

$$1 \text{ Kgf} = 9.806 \text{ N}$$

$$1 \text{ Kgf} = 2.205 \text{ lbf}$$

3.1.1.2 Torque: Data expressed in torque units may be interpreted via the definition of mechanical torque previously mentioned. Each strength value is presented as equivalent to a force times a distance. When a force or force component acting at right angles to the limb at a particular point must be known, it may be calculated by dividing the strength value by the distance to the force from the joint center. For example, an elbow flexion strength of 300 Kp-cm implies that the forearm can generate an upward force of 10 Kp at 30 cm away from the elbow, 15 Kp at 20 cm, 30 Kp at

10 cm, and so on. An estimate of the linkage length can be obtained from Section 3.2 to make an estimate of force capability for a particular age child. For sample calculations see Section 4.2 of this report. It must be kept in mind, however, that strict mathematical interpretation of torque may be erroneous for extremes of force and distance. In such cases a limitation of capability may be imposed by considerations other than absolute muscle strength. For example, very high loading pressure on the soft tissue can cause pain and thereby limit the strength capability. Also, exceeding the torque loading capability of a proximal joint may result in a limitation of the strength capability.

3.1.1.3 Motivation: Each strength value represents a maximum voluntary effort obtainable through verbal encouragement. It must be recognized that the child is capable of stronger efforts than the data indicate, especially in an excited psychological state. Section 2.8 of this report describes in detail motivation used in this study.

3.1.1.4 Strength Criteria: Each strength value is the average torque measured over a one second interval. This one second is selected as the one second interval which has the greatest average value of all possible contiguous one second intervals in a five second exertion. Section 2.5 describes the criteria in more detail.

3.1.1.5 Photograph of Test: A photograph of a child performing the test is presented to illustrate both the position of the child and the relevant straps on the fixture. The photographs are not intended to have any implications of the subject's motivation.

3.1.1.6 Description of the Tests: A precise anatomic definition of the strengths being measured is given with respect to the anatomic position. Figure 20 shows a subject in the anatomic position with illustration of the sagittal, coronal, and transverse planes together with their axes. Figure 21 contains definitions of terms used. All joint angles are defined to be zero when the subject assumes the anatomic position and rotates his wrist so that the palms face the thighs.

3.1.1.7 Test Position: The body position is described with respect to the anatomic position and joint angles are defined as zero in the anatomic position but with the wrists pronated so that the palms face the thighs. For a series of tests pertaining to one limb, only relevant joint positions for that limb are given. The rest of the body remains in the standard test position as shown in Figures 4 and 5. Grip and pinch tests are obtained with the right upper extremity unrestrained.

3.1.1.8 Anthropometric Measurement: These measurements are obtained in order to adjust the size of the strength chair. These measurements are described in detail in Section 3.2.

3.1.1.9 Adjustment of Equipment: The adjustment procedure necessary to fit the strength chair to a particular child is given. This is intended to help describe the system of body restraints provided by the strength chair.

3.1.1.10 Instructions to the Subject: The specific test instructions are given to the subject depending upon his or her level of comprehension. This section contains a condensed and stylized version of these instructions and does not reflect attempts to motivate the child. The topic of motivation is discussed in Section 2.8.

3.1.1.11 Sketch of Test: A drawing is presented to clarify the description of the test by illustrating, with some exaggeration, the motion attempted in performing the test.

3.1.1.12 Statistical Data: The page heading consists of a test name and a joint angle position as shown in the index. The data are represented by age groups from 2 1/2 to 10 1/2 years. The 15th and 85th percentiles were reported since the sample size in some age groups was insufficient to obtain a 5th or 95th percentile.

3.1.1.13 Graphs: The data is presented also as scatter plots of the individual strength values. Elbow strength was plotted against age, as is conveniently done. Plots against height, weight, and forearm length appear in Section 3.4.3. The scales are expanded to preserve the resolution

between individual points and therefore care must be taken when comparing graphs. Note that both elbow flexion and extension were measured in all positions except 180° where only flexion was measured.

Grip strength, the location of force, and the angle formed by the force vector with the center-line of the transducer are plotted against age for each setting of the transducer (2 cm, 3 cm, ...). These plots appear in Section 3.3.3.

3.1.1.14 Multiple Positions: Subsequent pages contain tables and plots of larger elbow angles. Means from these graphs at various pooled age groups are summarized across elbow position in Section 3.4.2.

3.1.1.15 Strength vs. Other Variables: Included in this section are plots of elbow flexion and extension vs. subject height, body weight, and the sum of the radial and carpal linkages, since this is a common lever arm in work performed by the hand. Also included in this section is elbow flexion and extension strength plotted against elbow joint angle.

In the graphs involving height, weight, and forearm linkage, scatter plots are used similar to previous sections. However, in addition to the individual data points, a linear regression line has been calculated and drawn in to fit the data. The purpose is meant to be for convenience and not to imply a first order fit is the best for the data. This line is labeled "Trend" on the graphs.

It should be noted that the representative elbow strength used for this set of plots involving height, weight, and linkage was that of the 112.5° position. This position was chosen since it represents the joint angle at which maximum strength appears to occur. Thus it represents a useful value to be compared with other body descriptors.

In the elbow flexion/extension vs. elbow joint angle plots, data from the preceding sections were pooled into convenient age groups of 2 1/2 to 5 years, 5 to 8 years, and 8 to 10 years. The pooled means were then plotted for each joint position tested and straight lines were used to connect points.

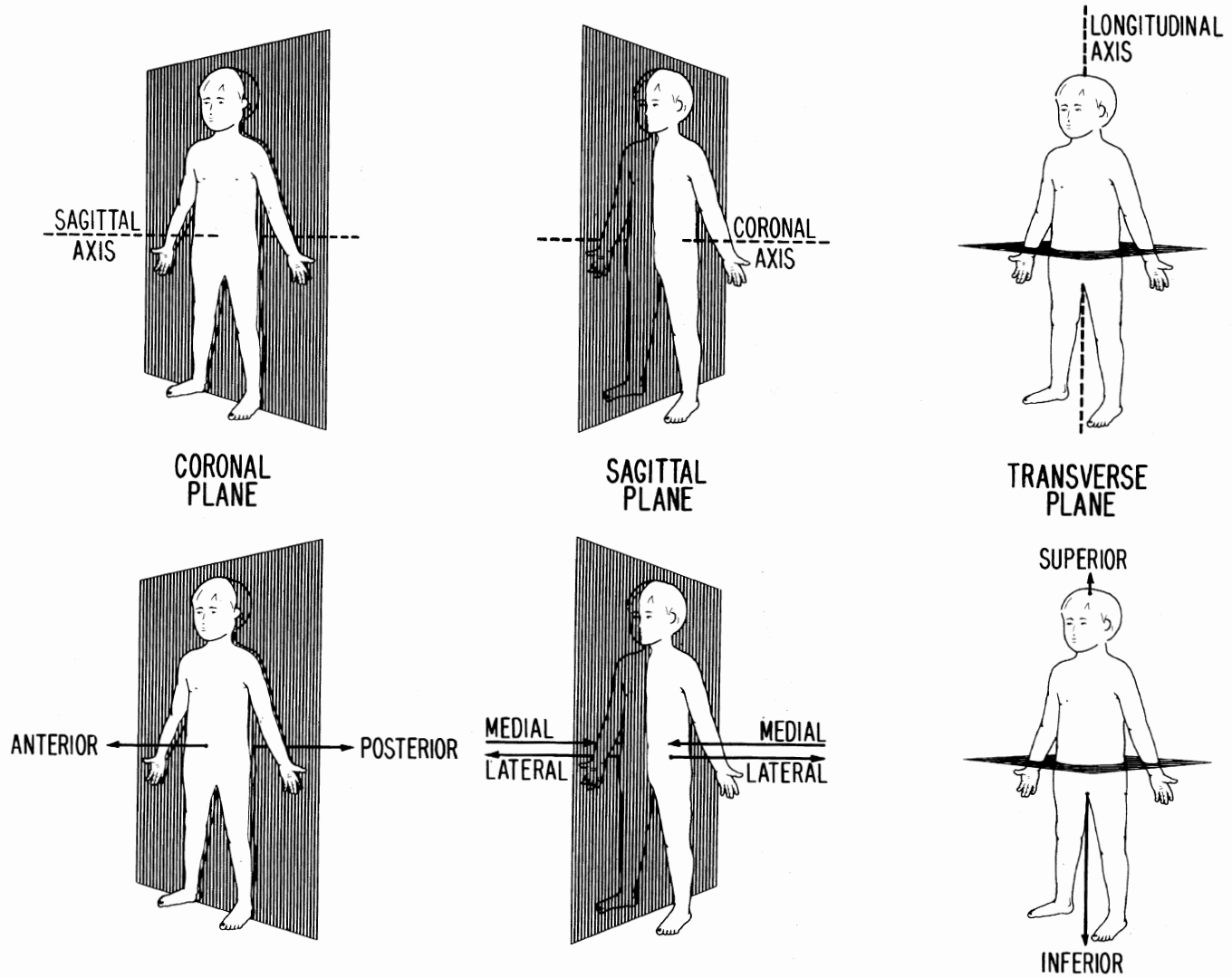


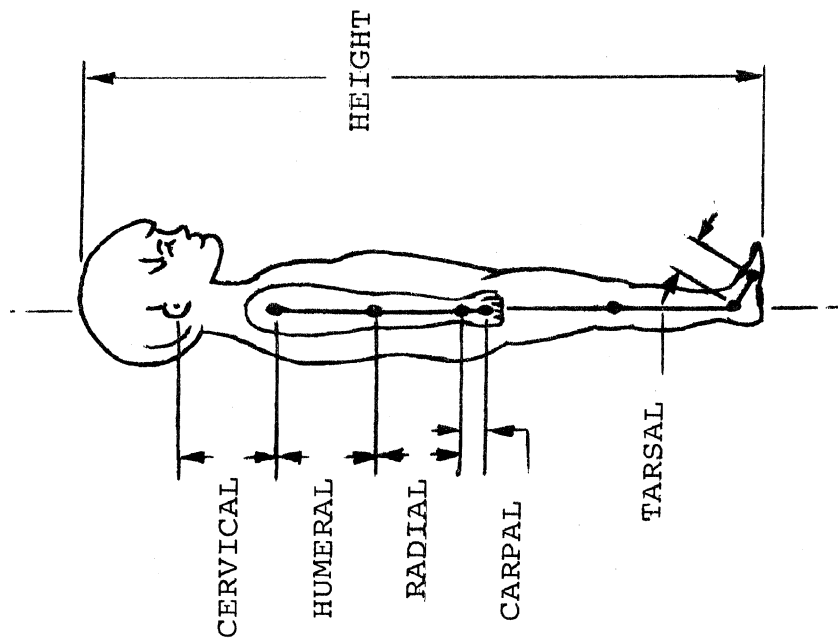
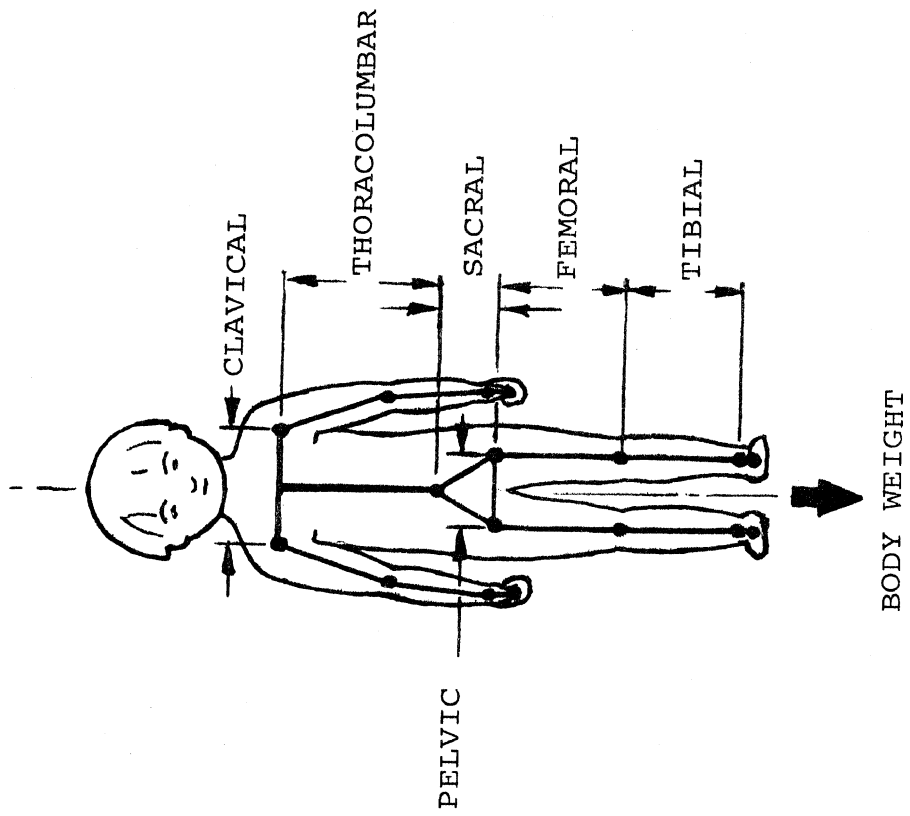
Figure 20 Anatomic Planes, Axes, and Directions

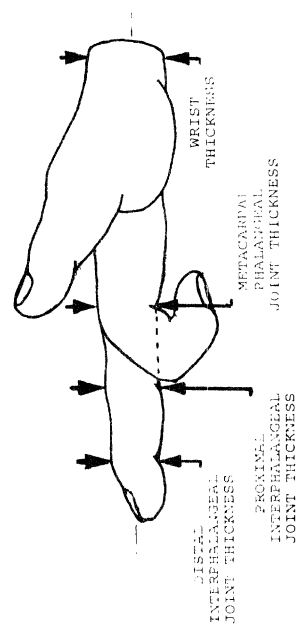
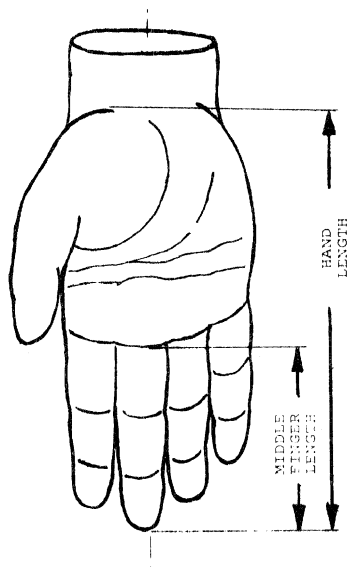
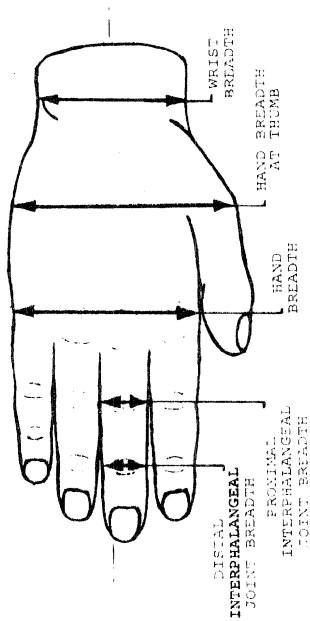
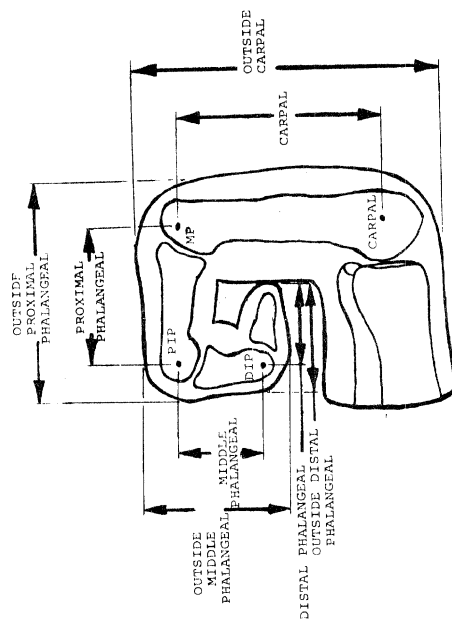
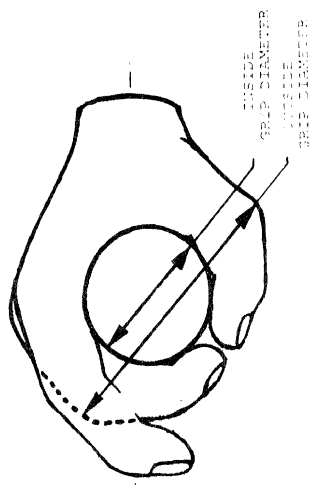


## 3.2 LINKAGE MEASUREMENTS

### 3.2.1 Index of Linkage Measurements

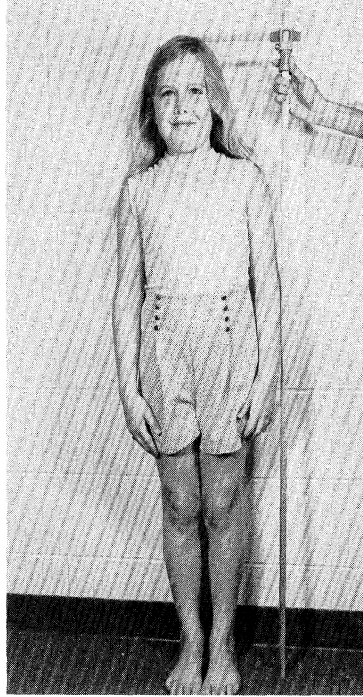
<u>Measurement</u>	<u>Page</u>
1. Standing Height .....	51
2. Body Weight .....	53
3. Carpal .....	55
4. Radial .....	57
5. Humeral .....	59
6. Sacral .....	61
7. Thoracolumbar .....	63
8. Cervical .....	65
9. Femoral .....	67
10. Tibial .....	69
11. Tarsal .....	71
12. Clavical .....	73
13. Pelvic .....	75
14. Wrist Breadth .....	77
15. Hand Breadth at Thumb .....	79
16. Hand Breadth .....	81
17. Finger Breadth at Proximal Interphalangeal Joint .....	83
18. Finger Breadth at Distal Interphalangeal Joint .....	85
19. Hand Length .....	87
20. Middle Finger Length .....	89
21. Wrist Thickness .....	91
22. Metacarpal Phalangeal Joint Thickness .....	93
23. Proximal Interphalangeal Joint Thickness .....	95
24. Distal Interphalangeal Joint Thickness .....	97
25. Third Phalanx .....	99
26. Proximal Phalangeal .....	101
27. Middle Phalangeal .....	103
28. Distal Phalangeal .....	105
29. Outside Carpal .....	107
30. Outside Proximal Phalangeal .....	109
31. Outside Middle Phalangeal .....	111
32. Outside Distal Phalangeal .....	113
33. Outside Grip Diameter .....	115
34. Inside Grip Diameter .....	117





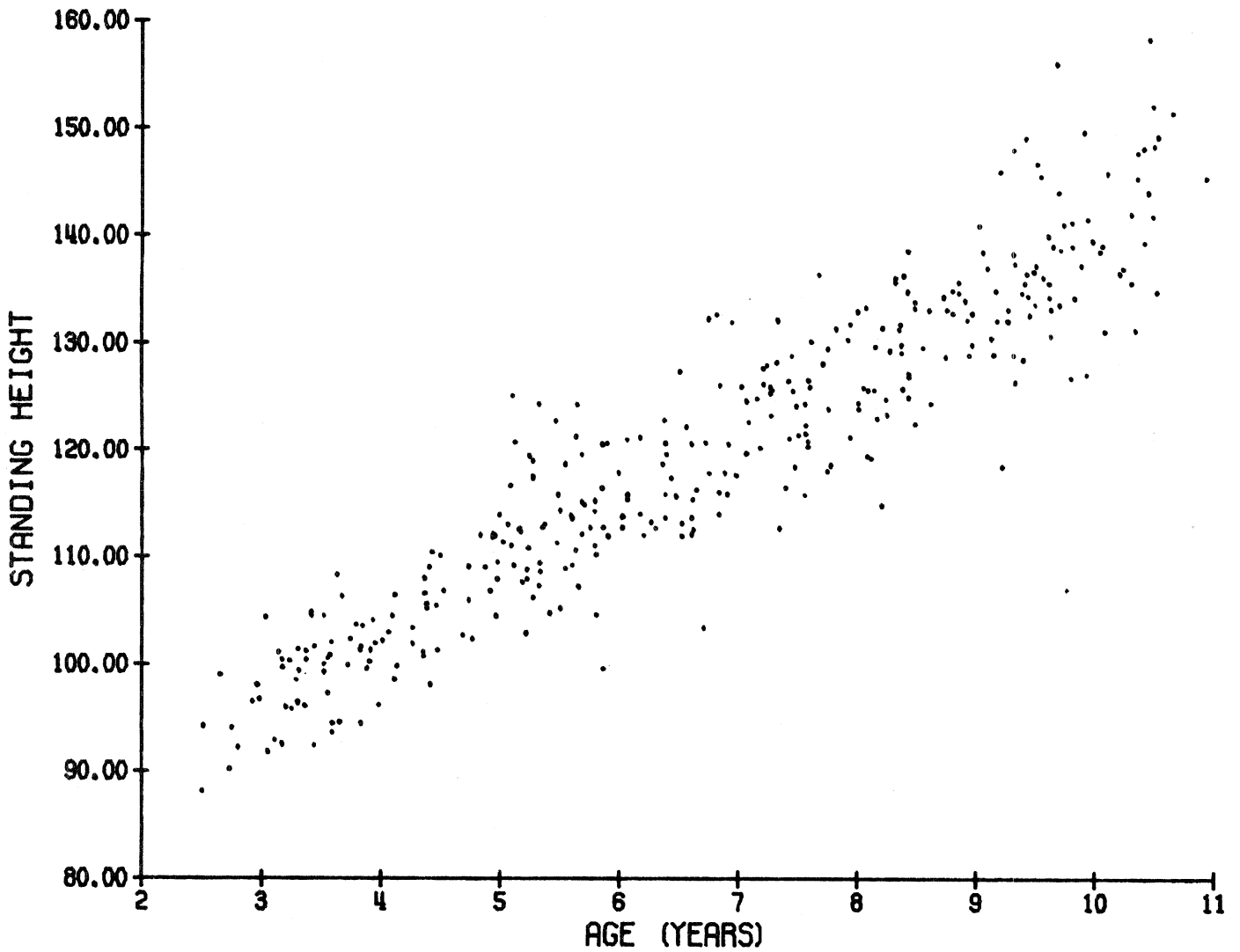
## STANDING HEIGHT

DESCRIPTION: Measure the perpendicular distance from the floor to the vertex with the child standing in bare feet or socks.



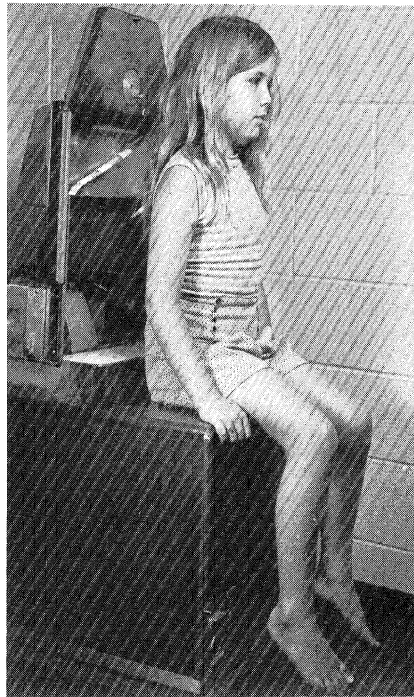
STANDING HEIGHT (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	97.3	4.3	88.1	89.3	96.6	104.5	104.9
3.5-4.5	45	102.1	4.1	93.6	94.2	101.7	108.8	110.4
4.5-5.5	44	111.4	5.5	102.3	102.7	111.0	122.3	125.0
5.5-6.5	49	114.5	4.8	99.6	104.9	113.8	121.2	124.2
6.5-7.5	46	121.3	6.5	103.4	112.0	121.0	131.9	132.5
7.5-8.5	52	126.8	5.7	114.7	117.0	125.8	136.0	138.4
8.5-9.5	42	133.7	5.6	118.3	124.4	133.0	145.2	148.9
9.5-10.5	45	140.5	7.2	126.6	127.8	139.2	151.6	158.0



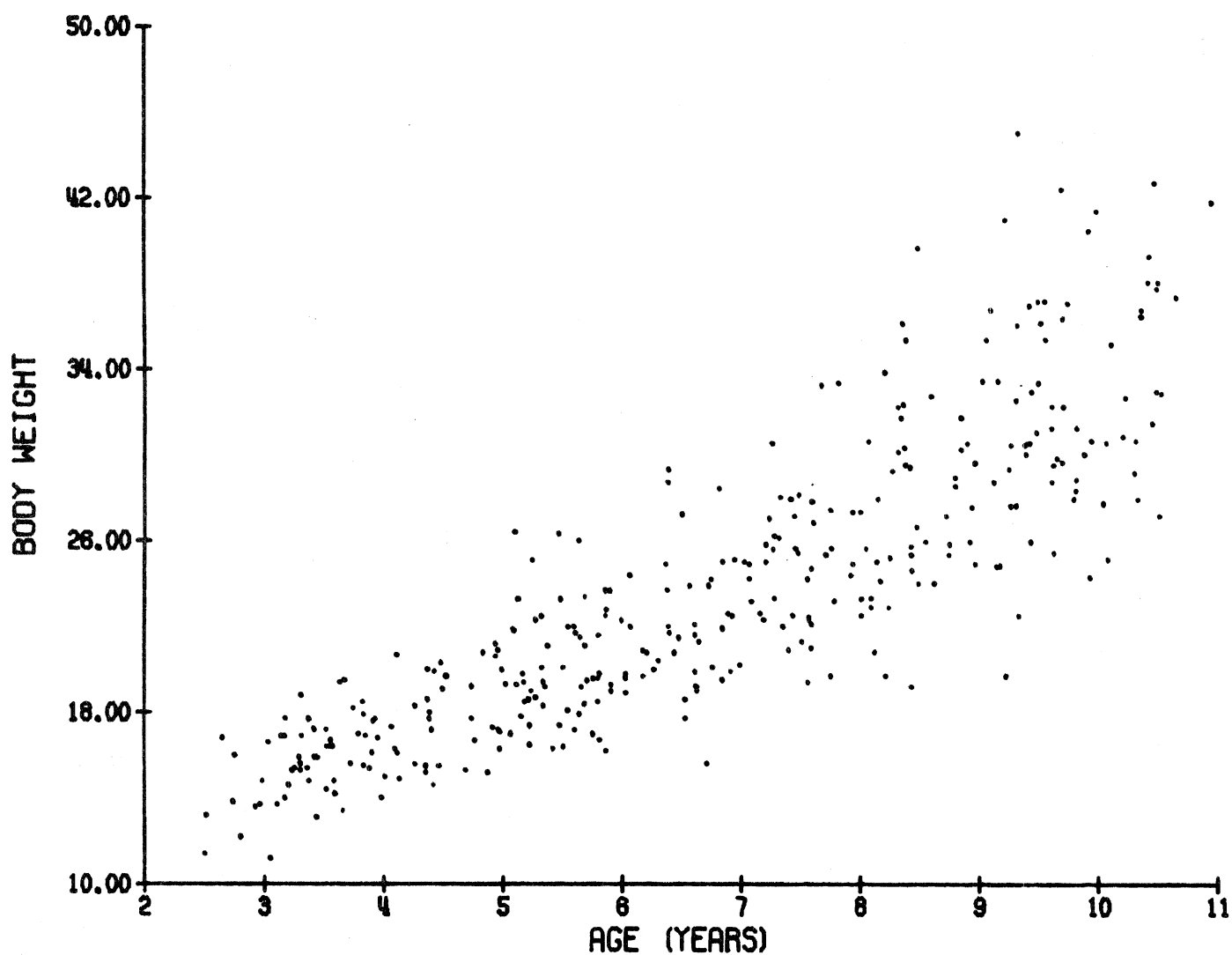
## BODY WEIGHT

DESCRIPTION: Seat subject on back side of chair with shoes off. Computer records voltage output from all four load cells supporting the chair. Remove the subject from chair. Computer similarly records empty chair weight. The difference between the two readings, the child's weight, is displayed on the graphics terminal and is stored.



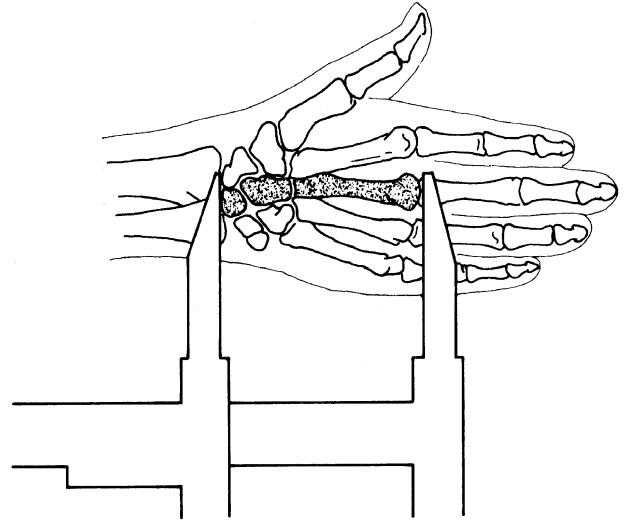
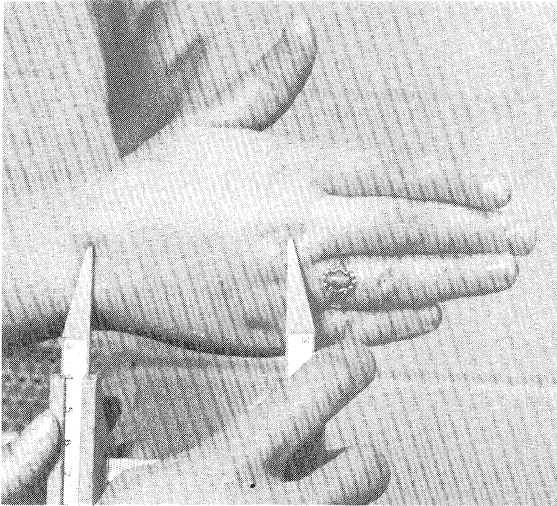
BODY WEIGHT (kg)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	15.2	1.9	11.2	11.3	15.3	17.6	18.8
3.5-4.5	45	16.8	1.9	13.4	14.0	16.5	20.0	20.7
4.5-5.5	44	19.6	2.7	15.2	15.4	19.2	24.7	26.4
5.5-6.5	49	21.0	2.8	16.2	16.5	20.7	25.5	29.3
6.5-7.5	46	23.4	3.2	15.6	18.0	23.3	28.1	30.5
7.5-8.5	52	26.4	4.7	19.2	19.5	25.2	34.4	39.6
8.5-9.5	42	30.1	5.0	19.7	22.6	30.0	37.1	44.9
9.5-10.5	45	33.0	4.9	24.3	25.2	31.6	41.6	42.6



## CARPAL LINKAGE

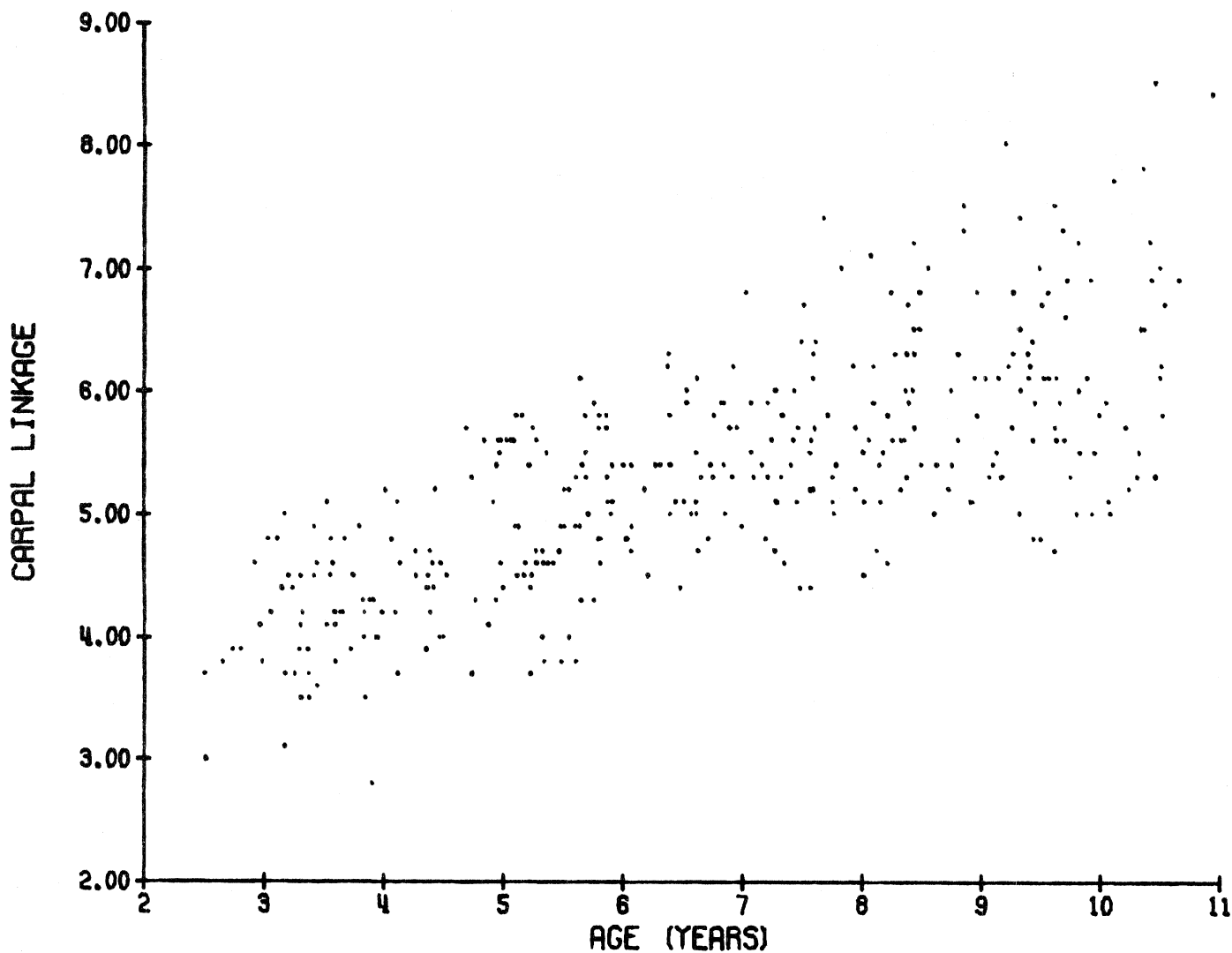
DESCRIPTION: Measure from the wrist (radiocarpal joint center) to the third knuckle (third carpophalangeal joint center).





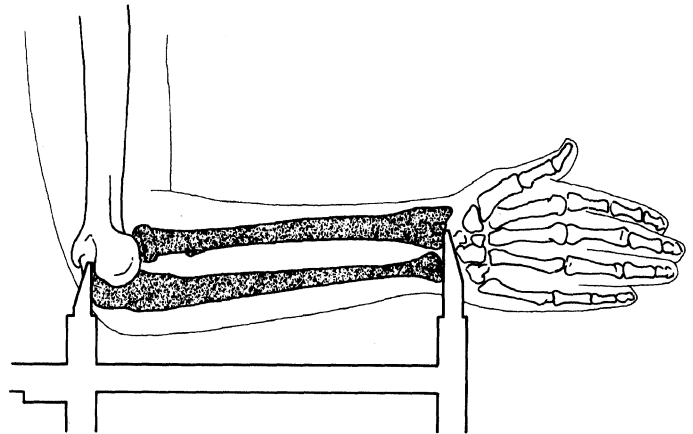
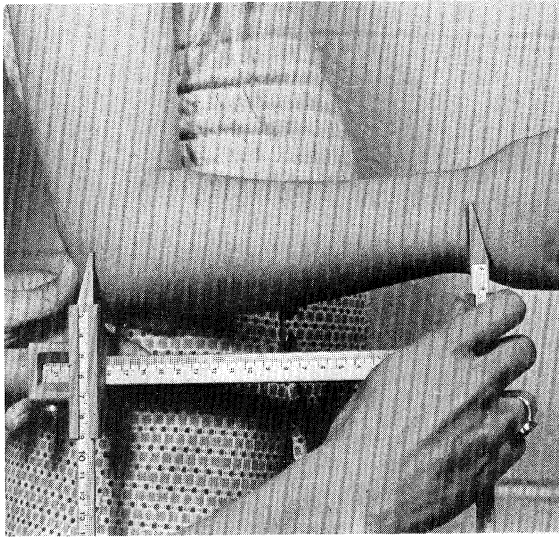
CARPAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	30	4.1	0.5	3.0	3.0	3.9	4.8	5.0
3.5-4.5	45	4.3	0.5	2.8	3.5	4.2	5.1	5.2
4.5-5.5	44	4.9	0.6	3.7	3.7	4.6	5.7	5.8
5.5-6.5	49	5.2	0.5	3.8	4.1	5.1	6.0	6.3
6.5-7.5	46	5.5	0.5	4.4	4.6	5.4	6.2	6.8
7.5-8.5	52	5.8	0.7	4.4	4.6	5.6	7.0	7.4
8.5-9.5	42	6.0	0.8	4.8	4.8	6.0	7.4	8.0
9.5-10.5	45	6.2	0.9	4.7	4.8	6.0	7.8	8.5



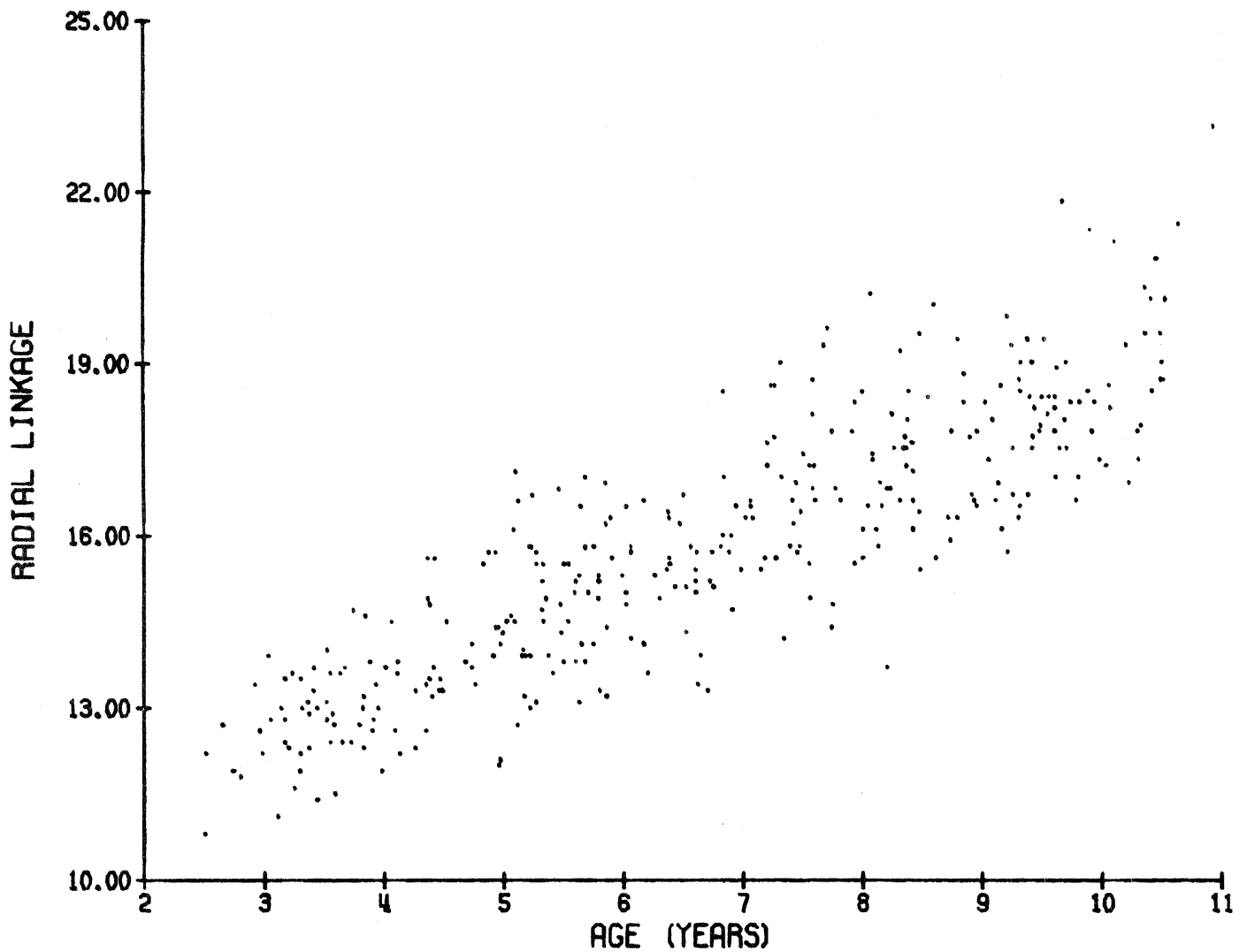
## RADIAL LINKAGE

DESCRIPTION: Measure from the elbow joint (humero-ulnar joint center) to the wrist (radiocarpal joint center).



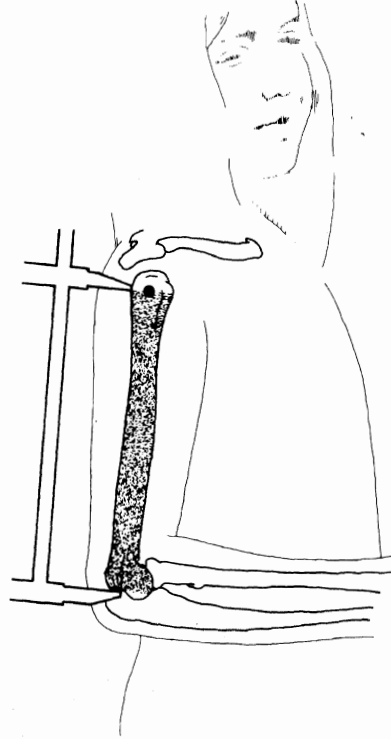
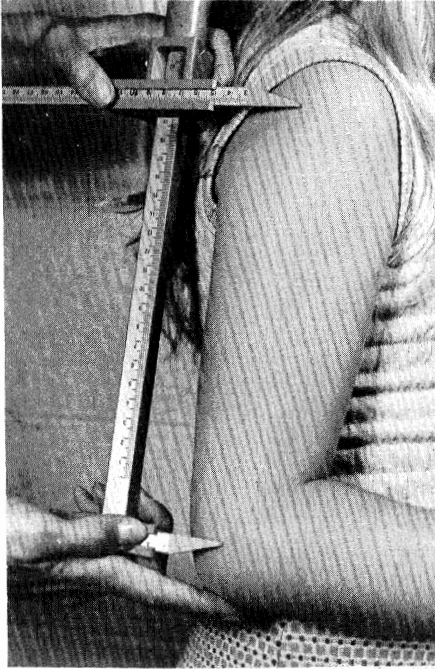
**RADIAL LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	12.5	0.8	10.8	11.0	12.5	13.6	13.9
3.5-4.5	45	13.3	0.9	11.5	11.6	13.2	14.9	15.6
4.5-5.5	44	14.6	1.2	12.0	12.2	14.4	16.7	17.1
5.5-6.5	49	15.2	1.0	13.1	13.2	15.2	16.6	17.0
6.5-7.5	46	16.0	1.3	13.3	13.5	15.7	18.5	19.0
7.5-8.5	52	17.0	1.4	13.7	14.6	16.9	19.4	20.2
8.5-9.5	42	17.7	1.2	15.6	15.7	17.7	19.4	20.0
9.5-10.5	45	18.8	1.5	16.6	16.9	18.4	21.4	23.1



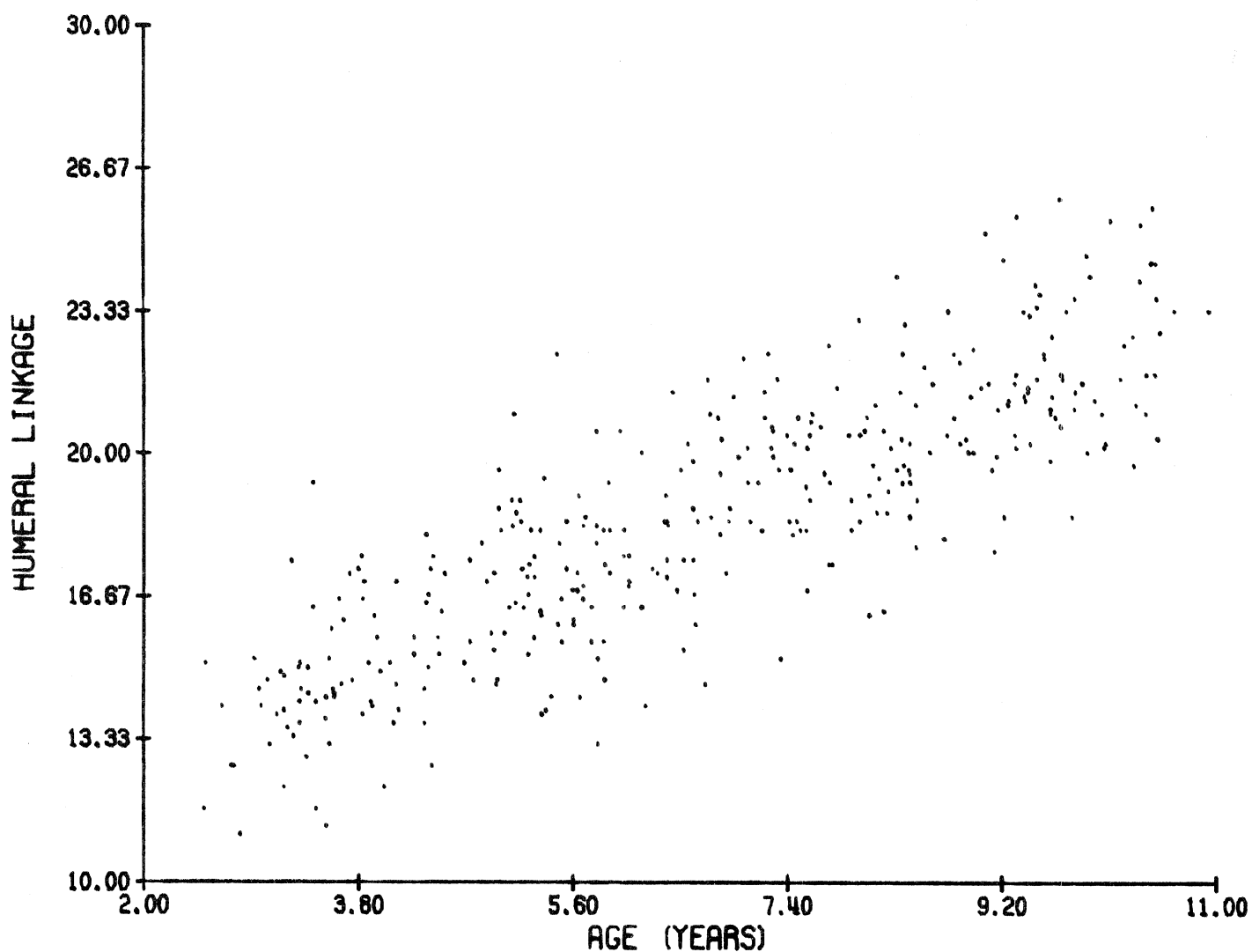
## HUMERAL LINKAGE

DESCRIPTION: Measure from the shoulder joint (glenohumeral joint center) to the elbow joint (humero-ulnar joint center).



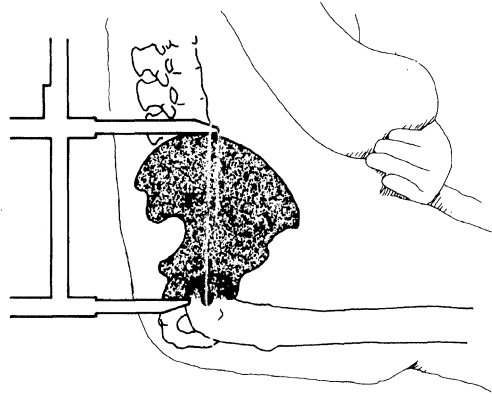
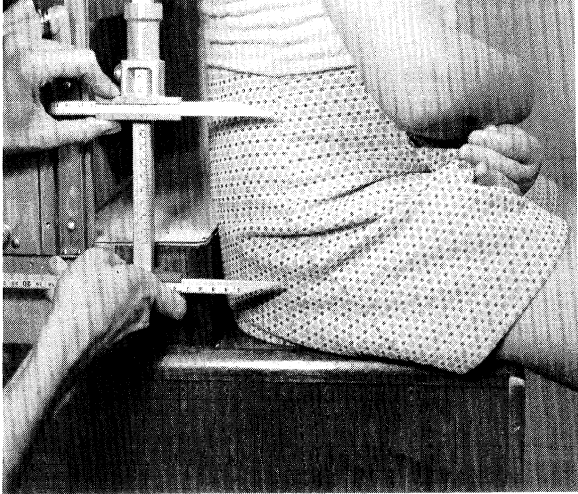
HUMERAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	14.2	1.6	11.1	11.3	14.1	16.9	19.3
3.5-4.5	45	15.2	1.5	11.3	12.3	15.1	17.4	18.1
4.5-5.5	44	17.0	1.8	13.9	14.1	17.0	19.6	22.3
5.5-6.5	49	17.3	1.6	13.2	14.2	17.2	20.1	21.4
6.5-7.5	46	19.2	1.8	14.6	15.3	19.5	21.7	22.3
7.5-8.5	52	19.7	1.6	16.2	16.6	19.5	22.7	24.1
8.5-9.5	42	21.4	1.7	17.7	18.0	21.2	24.4	25.5
9.5-10.5	45	22.2	1.8	18.5	19.7	21.7	25.4	25.9



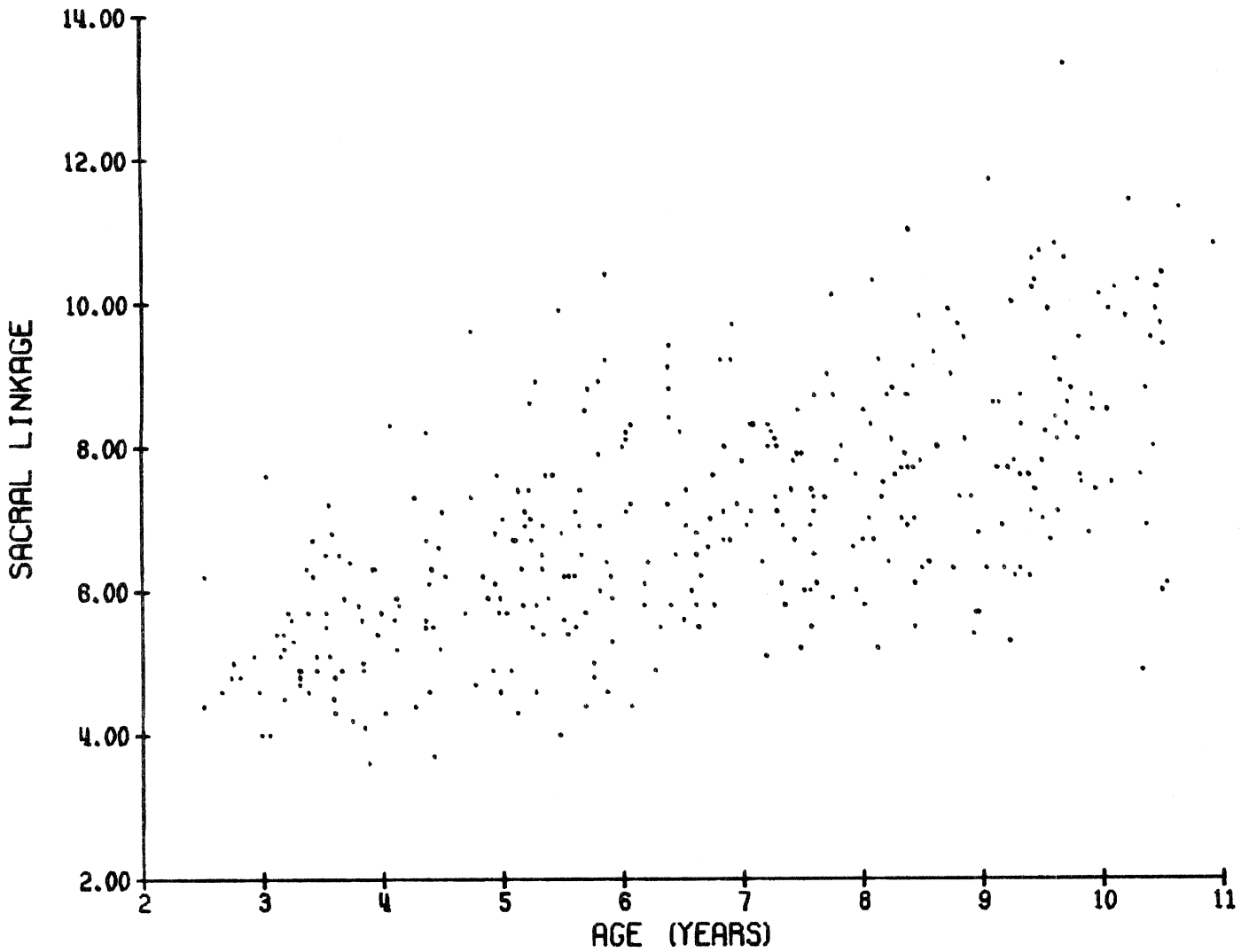
## SACRAL LINKAGE

DESCRIPTION: Measure from the hip joint (femoral head) to the hip top (crest of ilium).



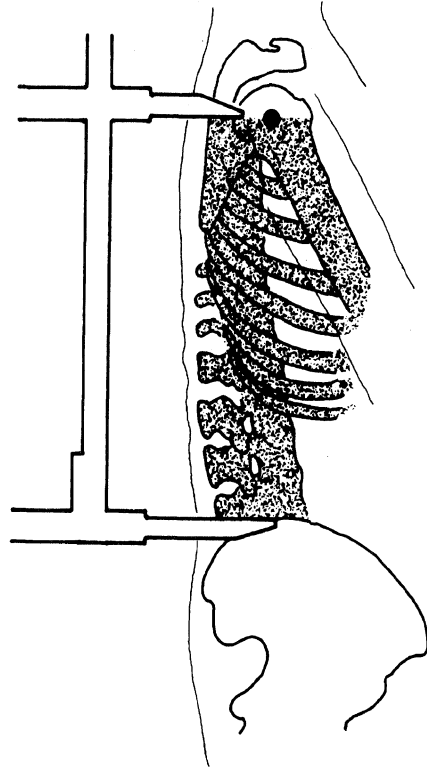
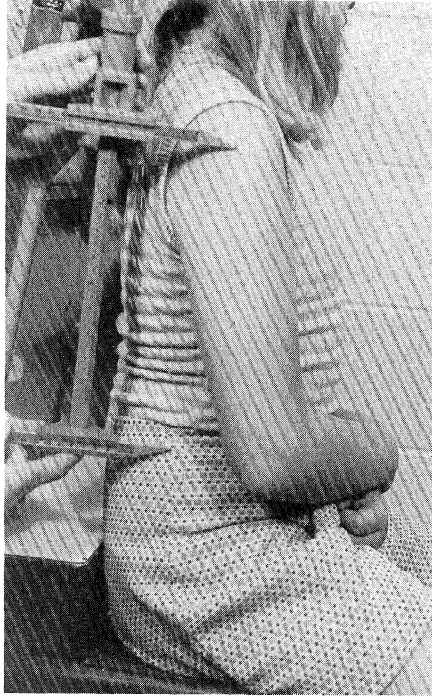
**SACRAL LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	5.2	0.8	4.0	4.0	4.9	6.5	7.6
3.5-4.5	44	5.7	1.1	3.6	3.8	5.6	7.3	8.3
4.5-5.5	44	6.5	1.3	4.0	4.3	6.3	8.8	9.9
5.5-6.5	49	6.9	1.5	4.4	4.5	6.5	9.2	10.4
6.5-7.5	46	7.2	1.1	5.1	5.3	7.0	8.7	9.7
7.5-8.5	52	7.5	1.3	5.2	5.4	7.4	9.9	11.0
8.5-9.5	42	7.9	1.6	5.3	5.4	7.6	10.6	11.7
9.5-10.5	45	8.8	1.6	4.9	6.0	8.7	11.2	13.3



## THORACOLUMBAR LINKAGE

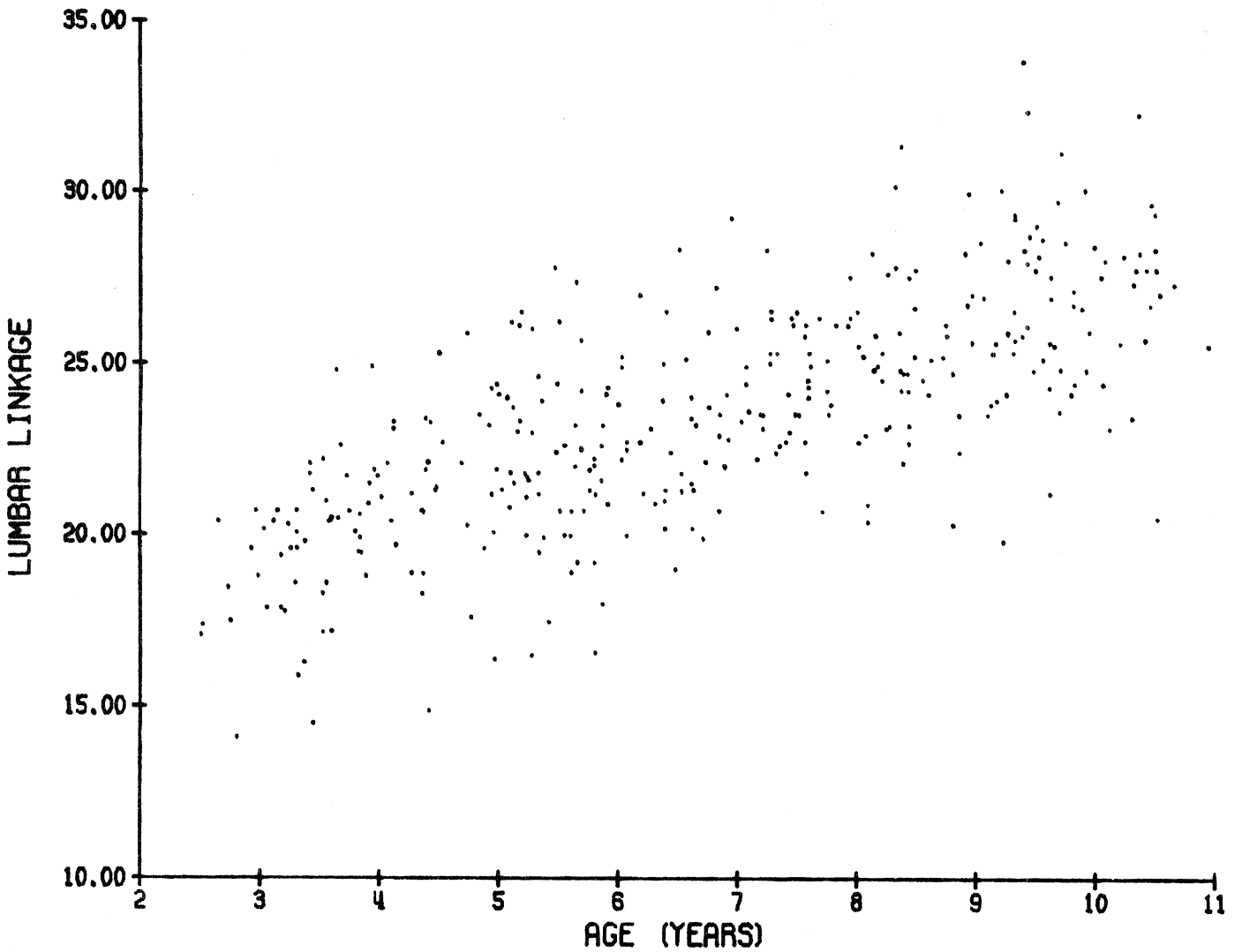
DESCRIPTION: Measure from the hip top (crest of the ilium) to the shoulder joint (glenohumeral joint center).





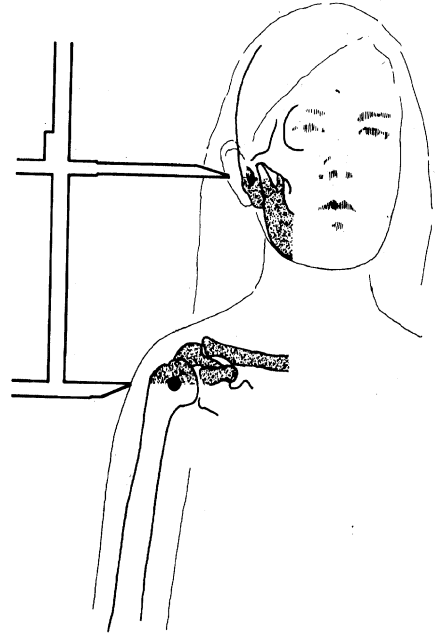
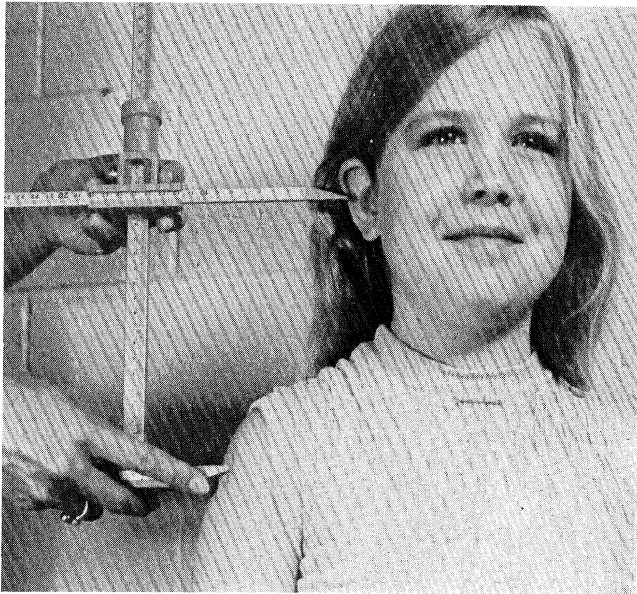
**THORACOLUMBAR LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	18.9	2.0	14.1	14.3	19.4	21.5	22.1
3.5-4.5	45	20.8	2.1	14.9	16.3	20.7	24.4	25.3
4.5-5.5	44	22.3	2.6	16.4	16.7	21.9	26.2	27.8
5.5-6.5	49	22.2	2.3	16.6	18.4	22.0	26.4	27.4
6.5-7.5	46	24.0	2.1	19.9	20.3	23.5	27.6	29.2
7.5-8.5	52	24.9	2.2	20.4	20.8	24.8	28.0	31.3
8.5-9.5	42	26.3	2.8	19.8	20.5	25.8	30.0	33.8
9.5-10.5	45	26.7	2.4	20.5	21.7	26.9	29.9	32.2



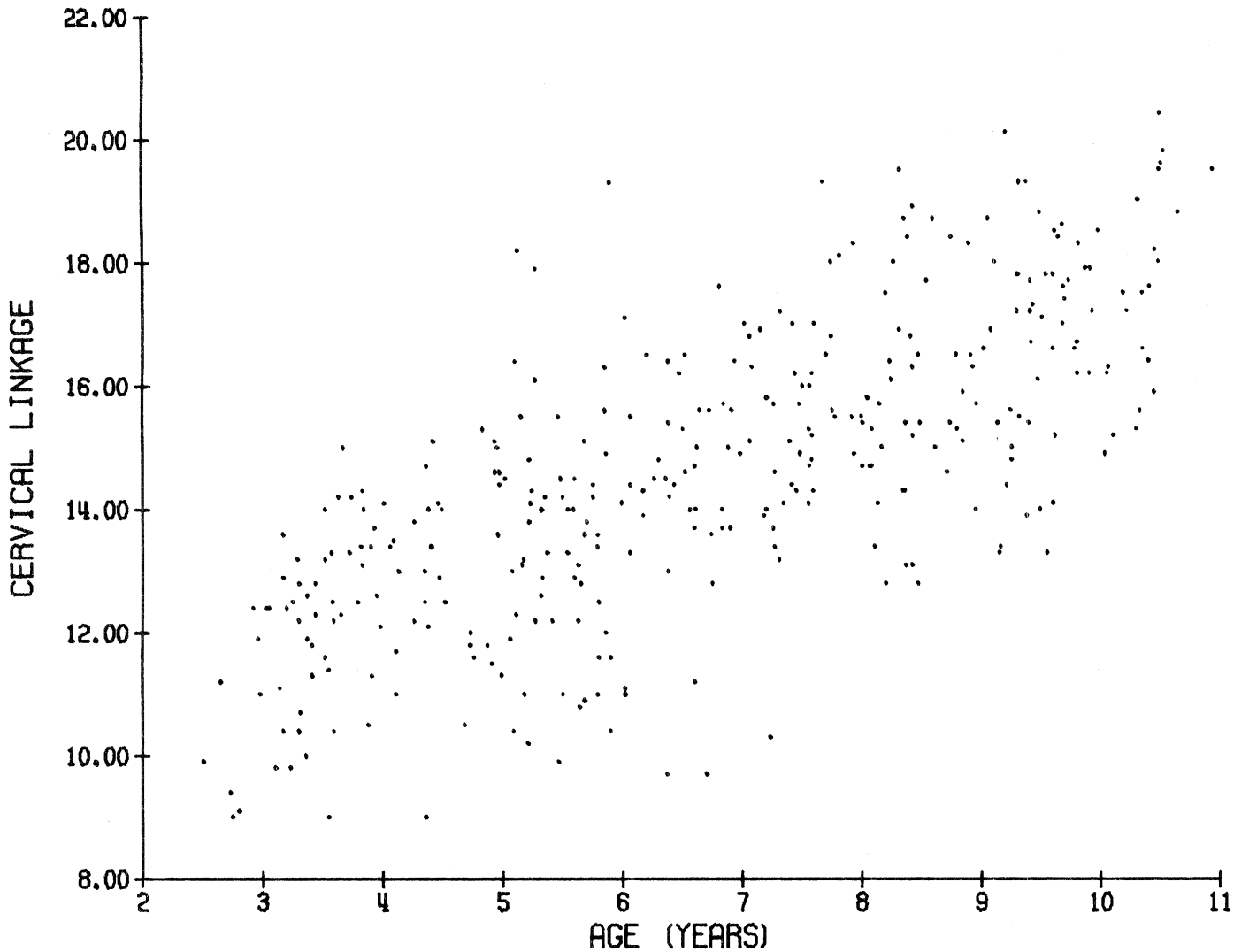
## CERVICAL LINKAGE

DESCRIPTION: Measure from the shoulder joint (glenohumeral joint center) to the ear canal (external auditory meatus).



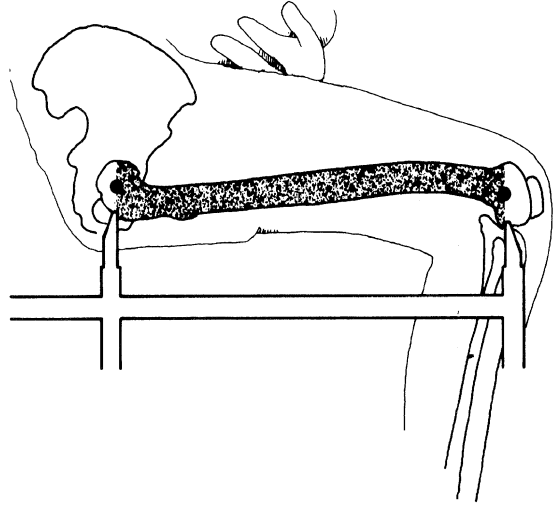
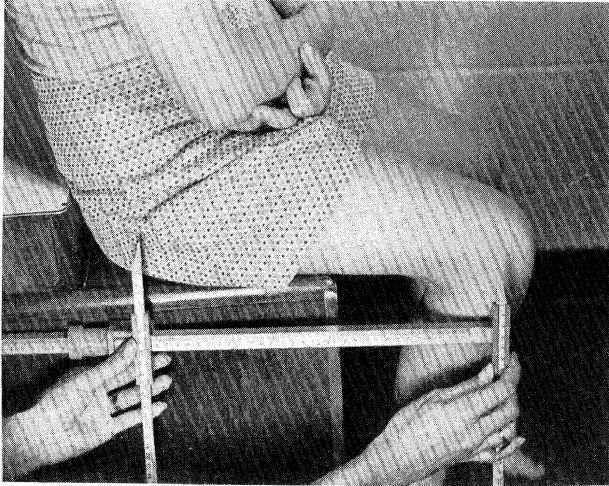
**CERVICAL LINKAGE (cm)**  
**(Males and Females)**

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	11.4	1.3	9.0	9.1	11.5	13.0	13.6
3.5-4.5	45	12.9	1.4	9.0	9.3	13.1	14.6	15.1
4.5-5.5	44	13.4	1.9	9.9	10.2	13.3	16.3	18.2
5.5-6.5	49	13.7	1.9	9.7	10.6	13.9	16.5	19.3
6.5-7.5	46	14.7	1.7	9.7	10.6	14.8	17.0	17.6
7.5-8.5	52	15.8	1.7	12.8	12.9	15.5	18.8	19.5
8.5-9.5	42	16.4	1.7	13.3	13.4	16.3	19.0	20.1
9.5-10.5	45	17.3	1.5	13.3	14.3	17.4	19.6	20.4



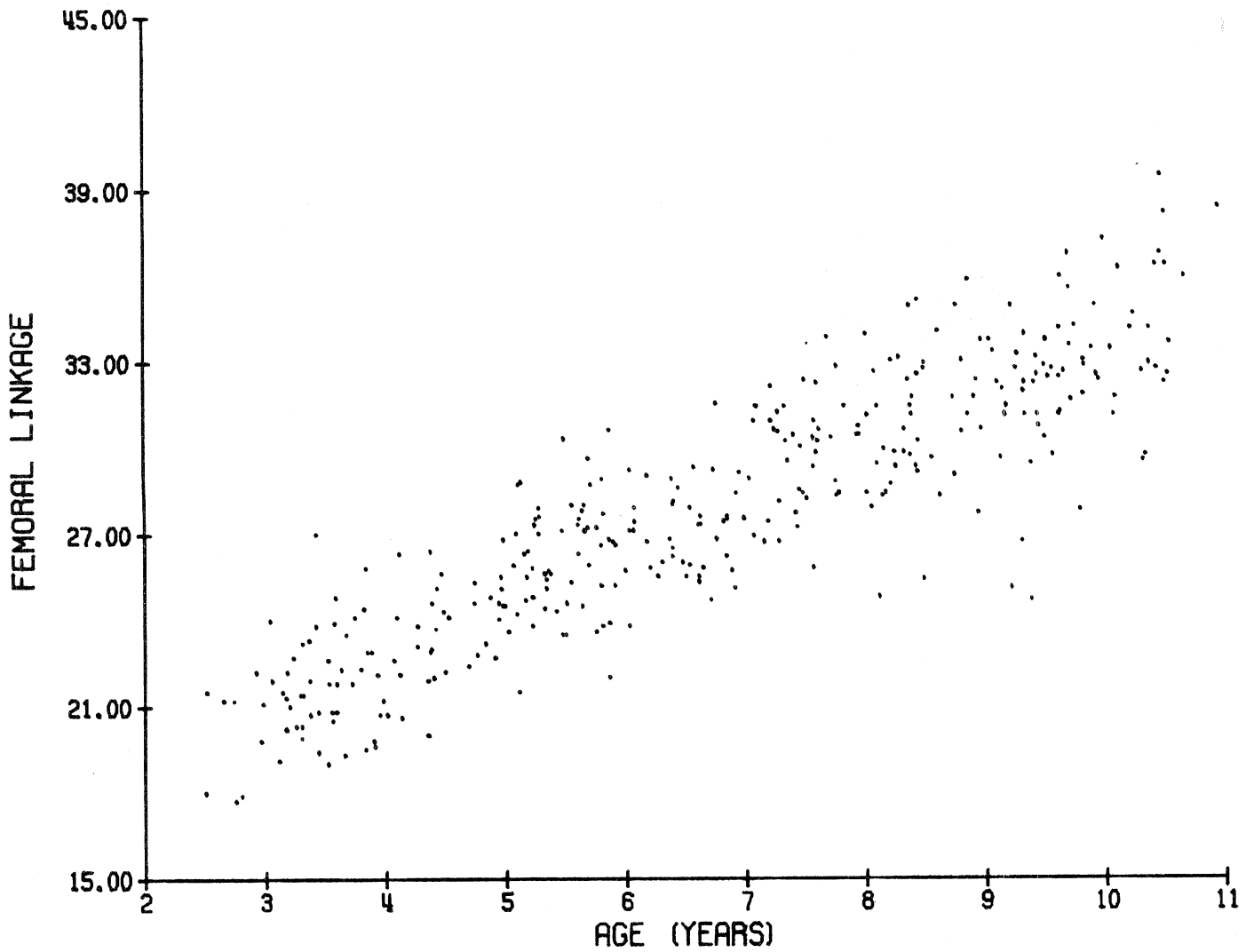
## FEMORAL LINKAGE

DESCRIPTION: Measure from the hip joint to the knee joint (femorotibial joint center).



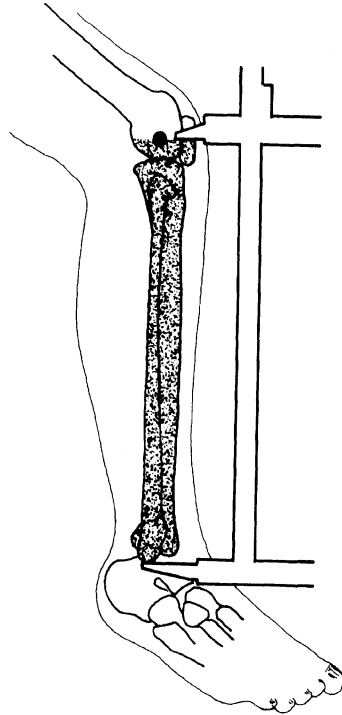
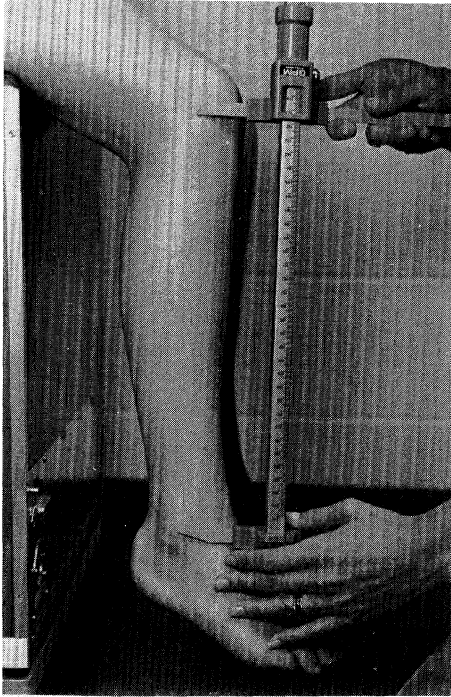
**FEMORAL LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	21.2	1.9	17.7	17.8	21.2	23.9	27.0
3.5-4.5	45	22.5	1.9	19.0	19.3	22.3	25.7	26.4
4.5-5.5	44	25.4	1.8	21.5	22.5	25.1	28.5	30.3
5.5-6.5	49	26.7	1.8	22.0	23.5	26.7	29.1	30.6
6.5-7.5	46	28.3	2.1	24.7	25.2	27.7	31.5	32.3
7.5-8.5	52	30.4	2.2	24.8	25.6	30.2	33.8	35.1
8.5-9.5	42	31.5	2.4	24.7	25.3	31.9	34.4	35.8
9.5-10.5	45	33.6	2.5	27.8	29.5	32.9	37.9	39.4



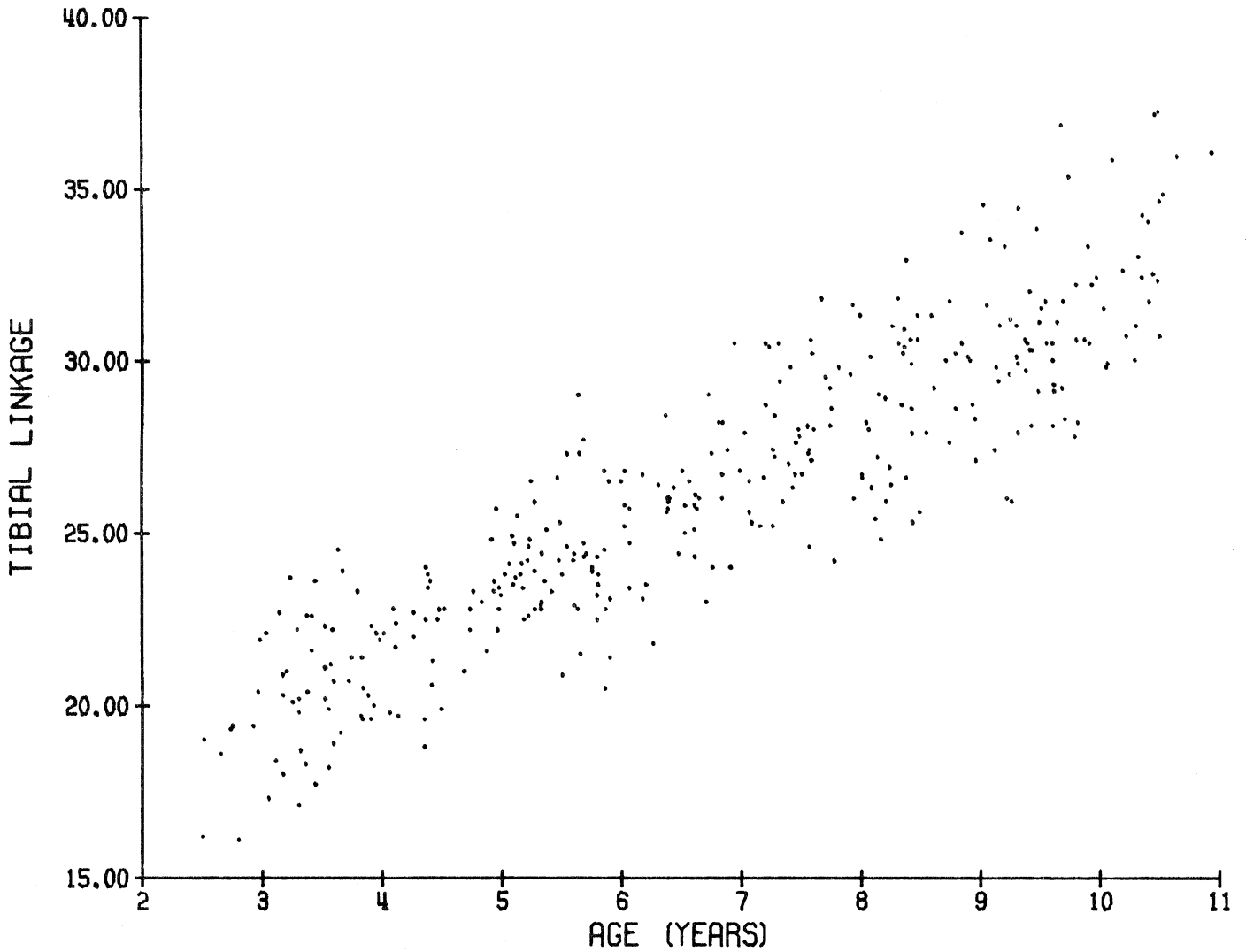
## TIBIAL LINKAGE

DESCRIPTION: Measure from the ankle joint (tibiotarsal joint center) to the knee joint (femorotibial joint center).



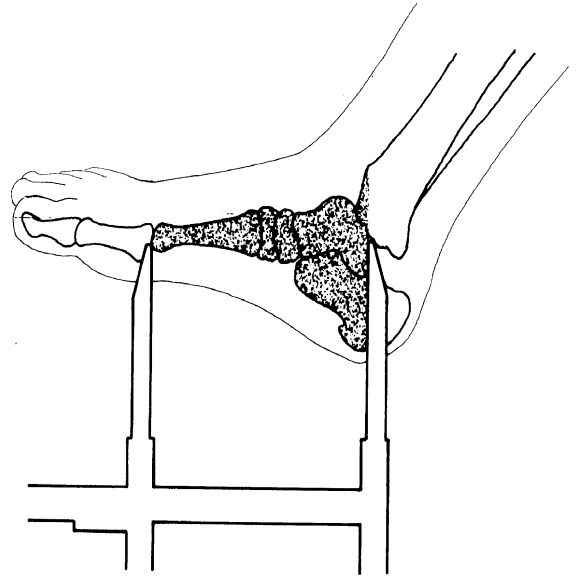
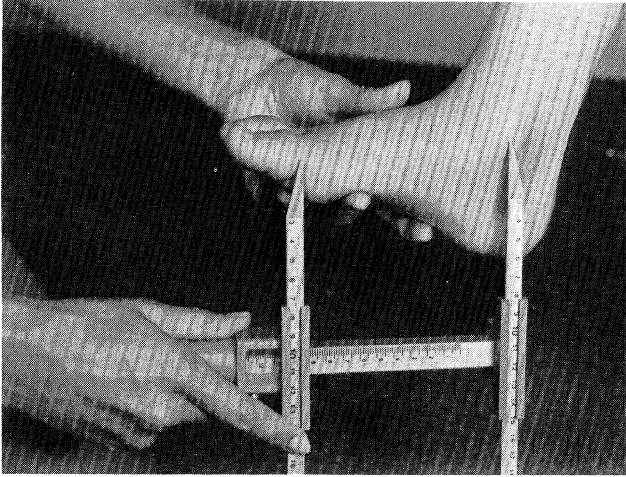
**TIBIAL LINKAGE (cm)**  
**(Males and Females)**

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	20.0	2.1	16.1	16.2	19.9	23.1	23.7
3.5-4.5	45	21.4	1.6	18.2	18.8	21.3	23.9	24.5
4.5-5.5	44	23.8	1.2	21.0	21.7	23.5	25.9	26.6
5.5-6.5	49	24.7	1.9	20.5	21.1	24.4	27.5	29.0
6.5-7.5	46	26.9	1.9	23.0	23.4	26.6	30.4	30.5
7.5-8.5	52	28.5	2.2	24.2	24.7	28.2	31.6	32.9
8.5-9.5	42	30.2	2.1	25.9	26.1	30.0	33.8	34.5
9.5-10.5	45	32.0	2.5	27.8	28.1	31.5	36.6	37.2



## TARSAL LINKAGE

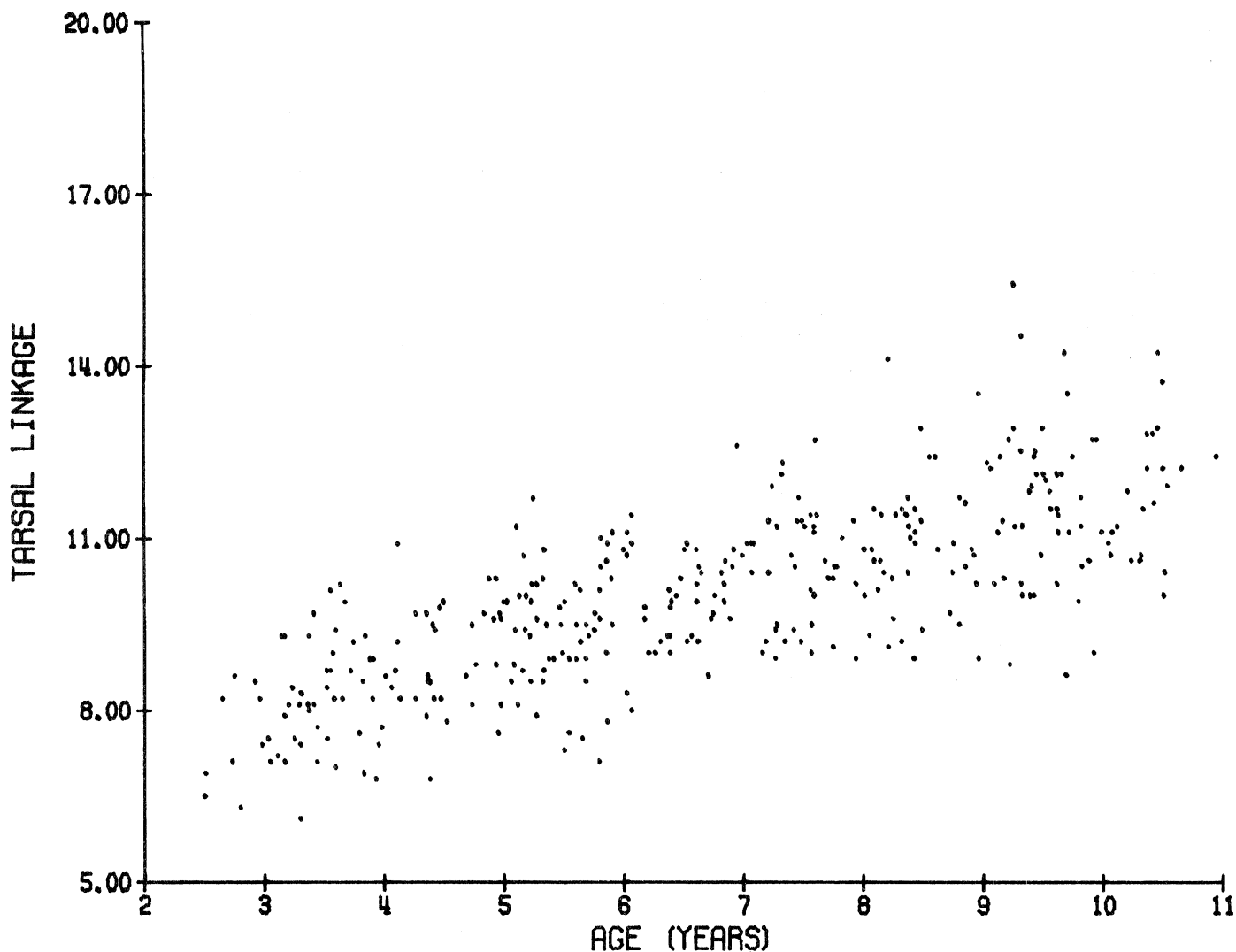
DESCRIPTION: Measure from the ball of the foot (first tarso-phalangeal joint center) to ankle joint (tibio-tarsal joint center).





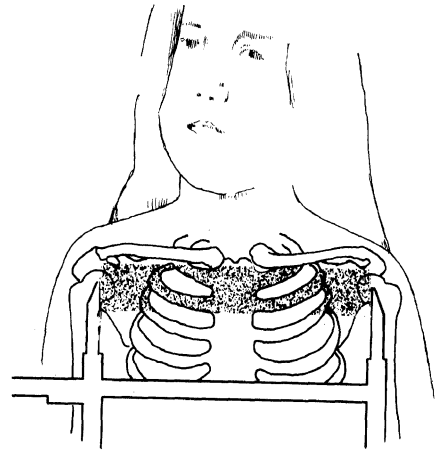
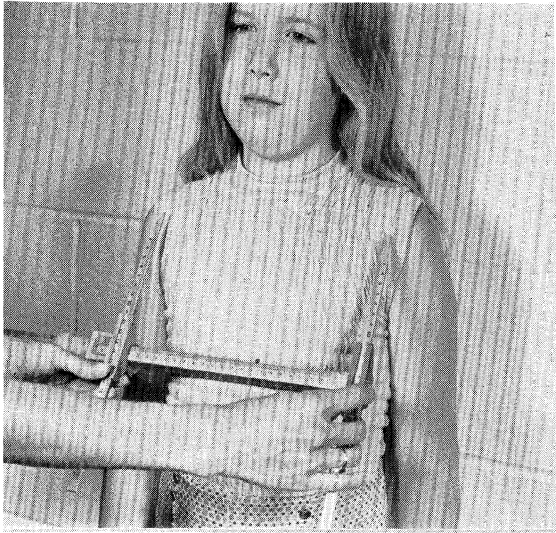
TARSAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	7.8	0.9	6.1	6.2	7.9	9.2	9.7
3.5-4.5	45	8.6	1.0	6.8	6.8	8.5	10.0	10.9
4.5-5.5	44	9.4	0.9	7.6	7.8	9.4	10.8	11.7
5.5-6.5	49	9.5	1.0	7.1	7.4	9.5	11.0	11.4
6.5-7.5	46	10.3	1.0	8.6	8.9	10.3	12.0	12.6
7.5-8.5	52	10.6	1.1	8.9	8.9	10.6	12.1	14.1
8.5-9.5	42	11.4	1.4	8.8	9.0	11.2	13.4	15.4
9.5-10.5	45	11.6	1.2	8.6	9.2	11.5	13.6	14.2



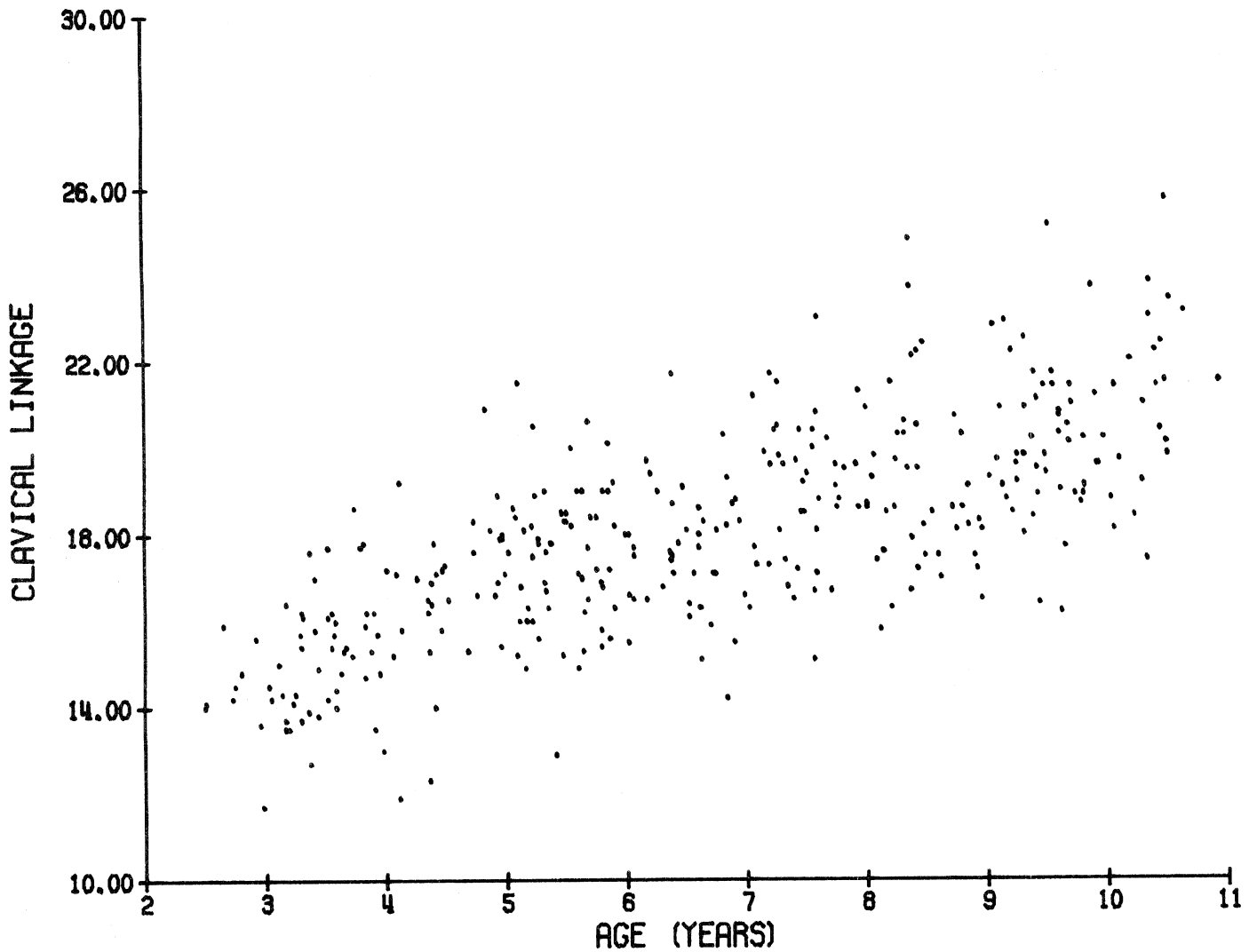
## CLAVICLE LINKAGE

DESCRIPTION: Measure from the left shoulder joint (left glenohumeral joint) to the right shoulder joint (right glenohumeral joint center). Subject standing.



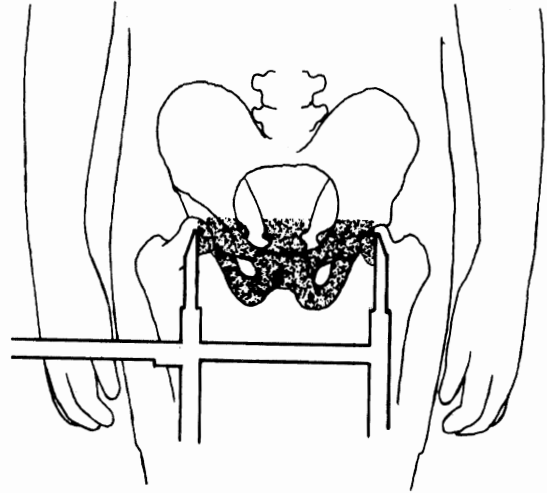
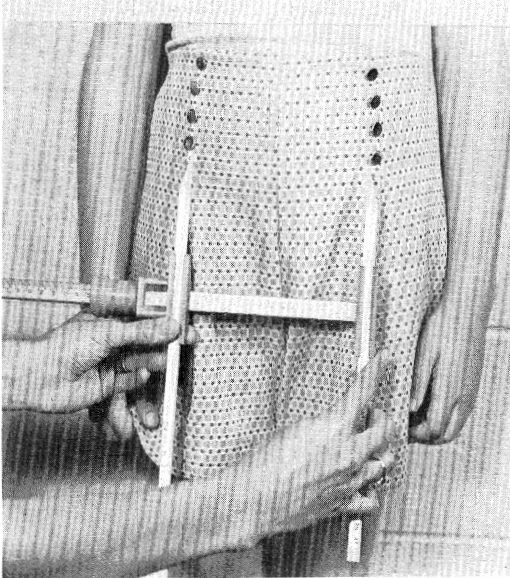
CLAVICAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	14.7	1.3	11.7	12.2	14.3	16.7	17.6
3.5-4.5	45	15.8	1.6	11.9	12.5	15.8	17.8	19.2
4.5-5.5	44	17.3	1.6	12.9	14.9	17.5	20.2	21.5
5.5-6.5	49	17.8	1.5	14.9	15.3	17.6	20.1	21.7
6.5-7.5	46	18.1	1.7	14.2	15.2	18.1	21.0	21.7
7.5-8.5	52	19.3	2.0	15.1	16.1	19.3	22.6	24.8
8.5-9.5	42	19.4	1.6	16.4	16.5	19.2	22.5	22.9
9.5-10.5	45	20.7	2.0	16.2	17.5	20.4	23.8	25.7



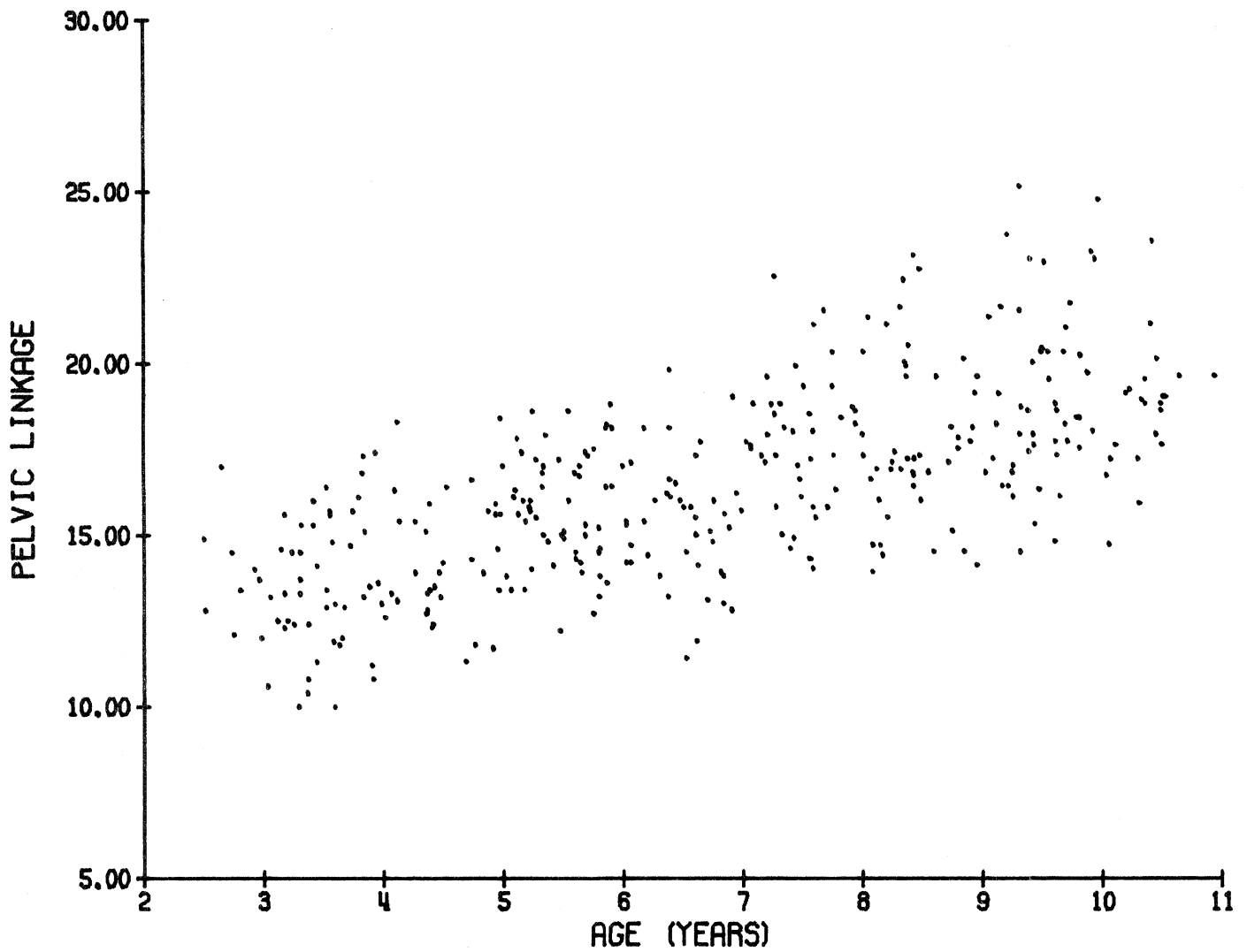
## PELVIC LINKAGE

DESCRIPTION: Measure from the left hip joint (left femoral head) to the right hip joint (right femoral head). Subject standing.



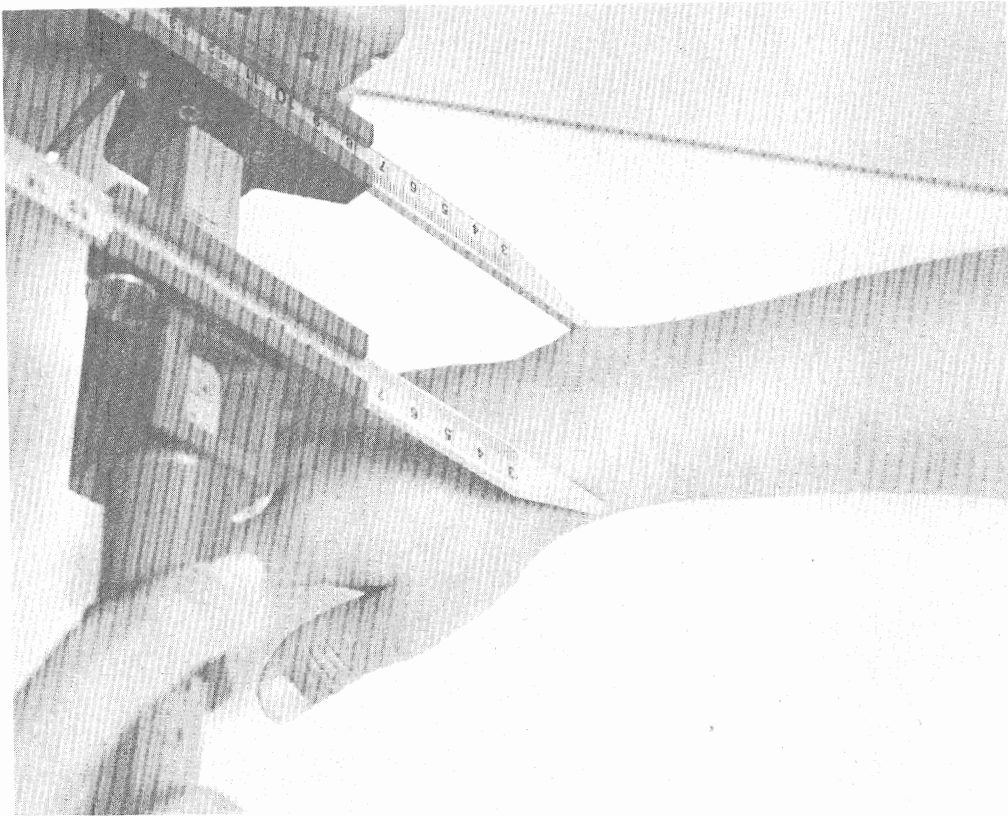
PELVIC LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	13.3	1.7	10.0	10.2	13.3	15.8	17.0
3.5-4.5	45	14.0	1.8	10.0	10.9	13.4	17.2	18.3
4.5-5.5	44	15.4	1.8	11.3	11.7	15.6	17.9	18.6
5.5-6.5	49	15.8	1.7	12.7	13.1	15.5	18.4	19.8
6.5-7.5	46	16.3	2.2	11.4	12.2	16.0	19.4	22.5
7.5-8.5	52	17.9	2.4	13.9	14.1	17.2	21.9	23.1
8.5-9.5	42	18.2	2.5	14.1	14.2	17.8	22.9	25.1
9.5-10.5	45	19.1	2.2	14.7	15.1	18.8	23.1	24.7



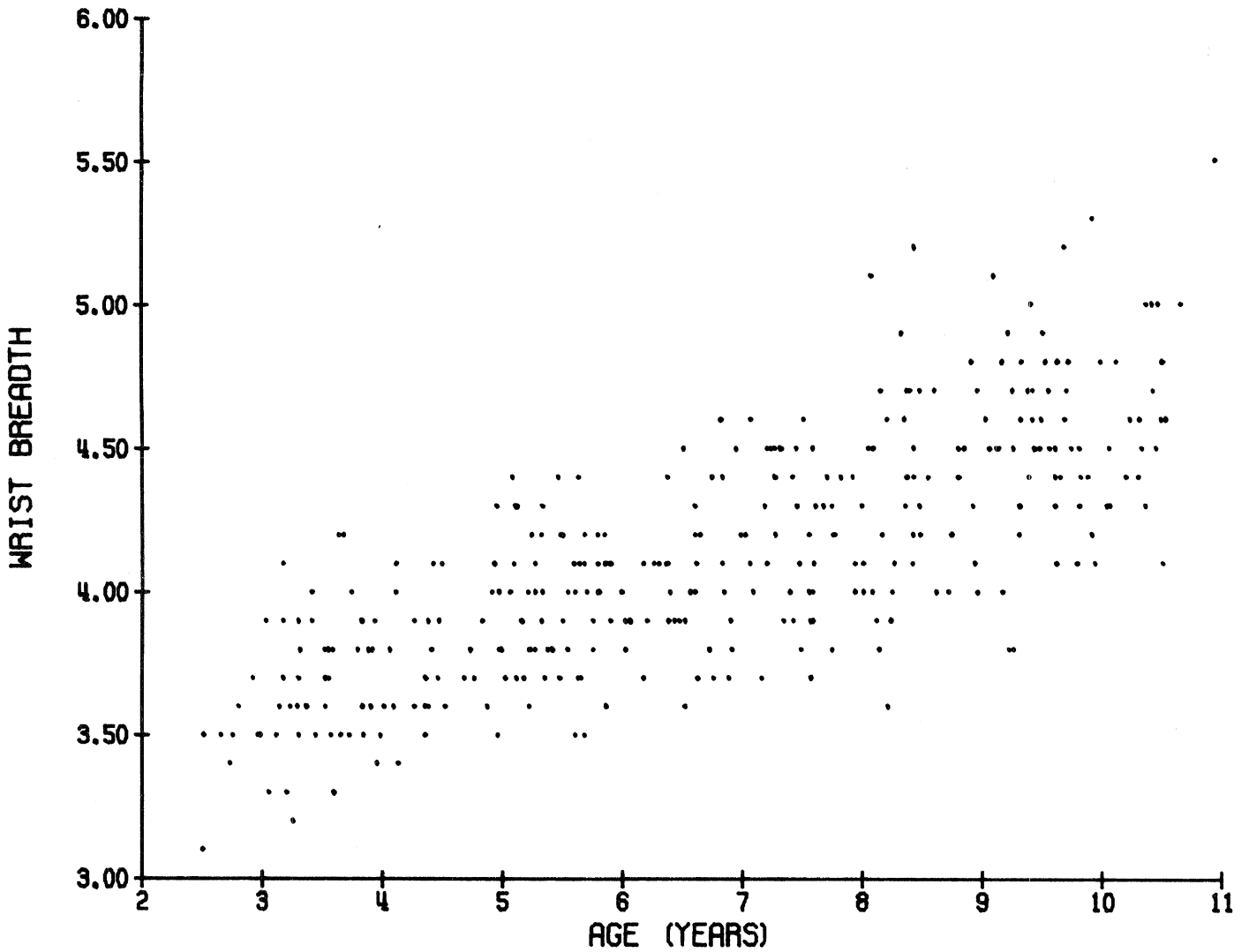
## WRIST BREADTH

DESCRIPTION: Measure the maximum width of the wrist across the radius and ulna at the distal end of the radius and ulna.



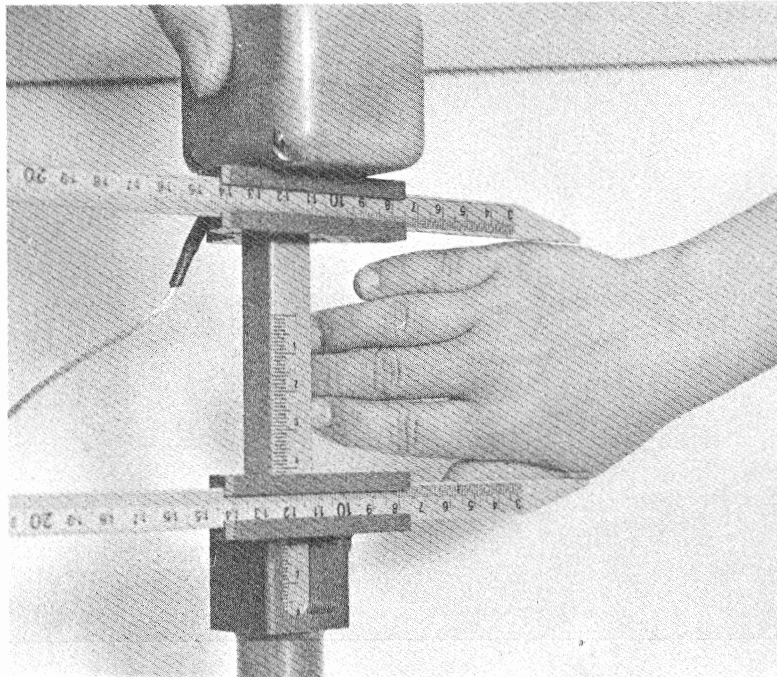
**WRIST BRFADTH (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	3.6	0.2	3.1	3.2	3.5	3.9	4.1
3.5-4.5	45	3.7	0.2	3.3	3.3	3.7	4.1	4.2
4.5-5.5	44	3.9	0.2	3.5	3.5	3.8	4.3	4.4
5.5-6.5	49	4.0	0.2	3.5	3.5	3.9	4.2	4.4
6.5-7.5	45	4.2	0.3	3.6	3.6	4.1	4.5	4.6
7.5-8.5	52	4.3	0.3	3.6	3.7	4.2	4.8	5.2
8.5-9.5	42	4.5	0.3	3.8	3.8	4.4	4.9	5.1
9.5-10.5	45	4.6	0.3	4.1	4.1	4.5	5.1	5.5



## HAND BREADTH AT THUMB

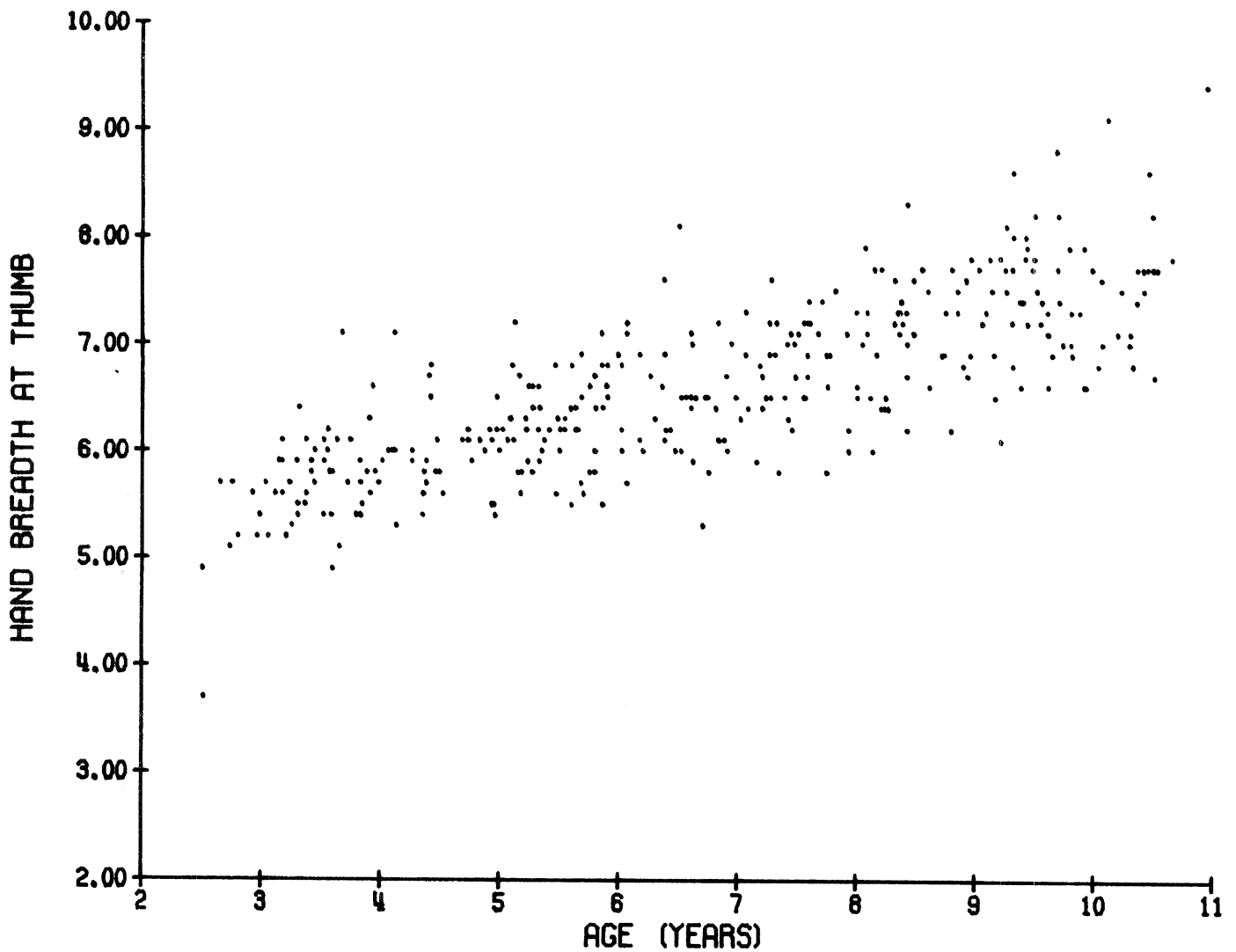
DESCRIPTION: Measure the maximum width of the hand at the second knuckle of the thumb (metacarpal-phalangeal joint of phalanx I) with the thumb fully adducted.





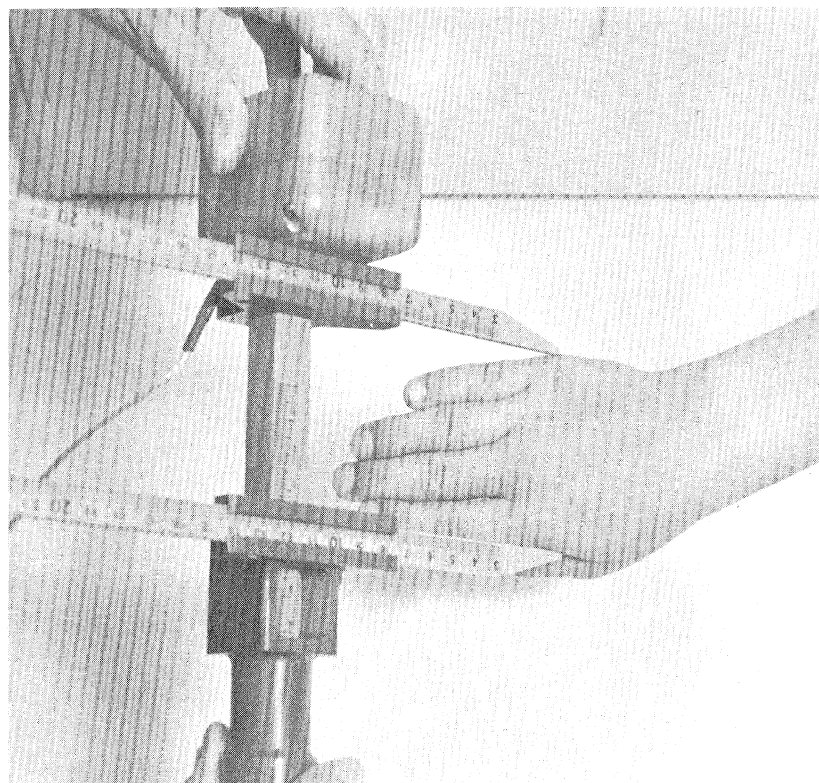
HAND BREADTH-THUMB (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	5.5	0.5	3.7	4.4	5.6	6.1	6.4
3.5-4.5	45	5.9	0.5	4.9	5.1	5.8	6.8	7.1
4.5-5.5	44	6.1	0.4	5.4	5.5	6.1	6.7	7.2
5.5-6.5	49	6.4	0.5	5.5	5.5	6.3	7.1	7.6
6.5-7.5	46	6.6	0.5	5.3	5.6	6.5	7.3	8.1
7.5-8.5	51	7.0	0.5	5.8	6.0	7.0	7.7	8.3
8.5-9.5	42	7.4	0.6	6.1	6.2	7.4	8.1	8.6
9.5-10.5	45	7.5	0.6	6.6	6.6	7.3	8.7	9.4



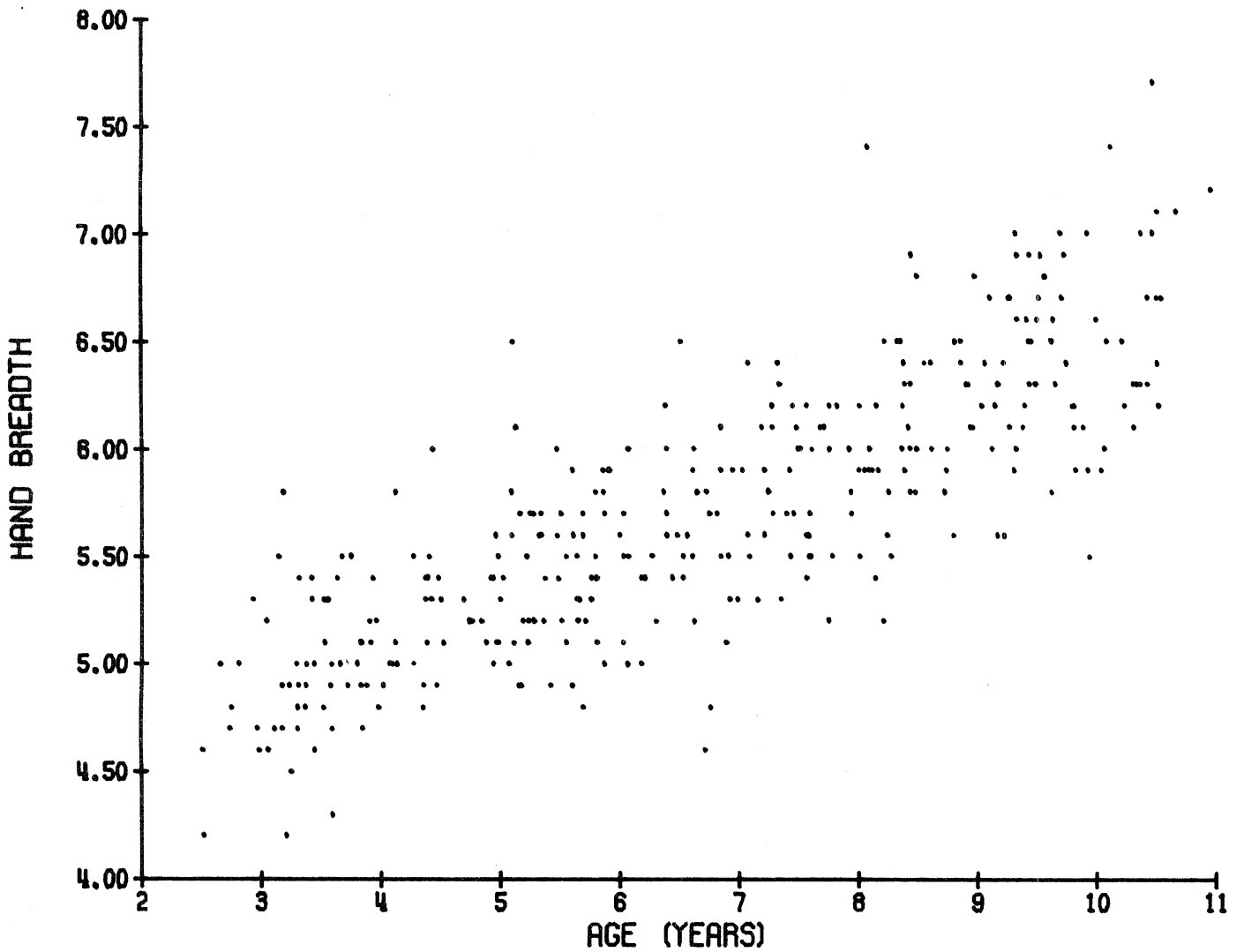
## HAND BREADTH

DESCRIPTION: Measure the maximum width of the hand at the third knuckle of the first finger (metacarpal phalangeal joint center of phalanx II).



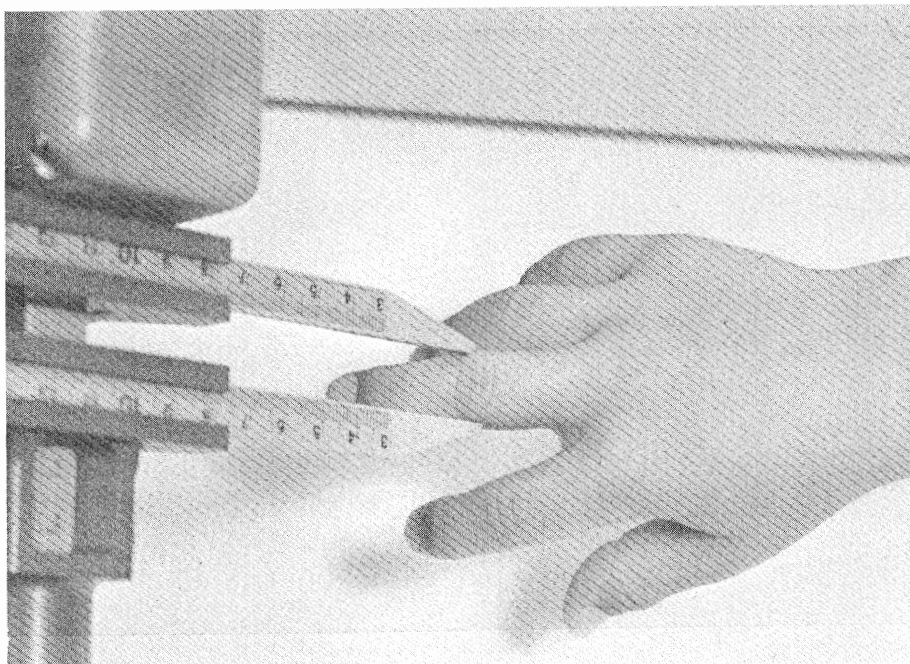
**HAND BREADTH (cm)**  
**(Males and Females)**

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	4.9	0.4	4.2	4.2	4.8	5.4	5.8
3.5-4.5	45	5.1	0.3	4.3	4.5	5.0	5.5	6.0
4.5-5.5	44	5.4	0.3	4.9	4.9	5.2	6.0	6.5
5.5-6.5	49	5.5	0.3	4.8	4.9	5.5	5.9	6.2
6.5-7.5	46	5.7	0.4	4.6	4.9	5.7	6.3	6.5
7.5-8.5	52	6.0	0.4	5.2	5.3	5.9	6.6	7.4
8.5-9.5	42	6.3	0.4	5.6	5.6	6.3	6.8	7.0
9.5-10.5	45	6.5	0.5	5.5	5.8	6.4	7.2	7.7



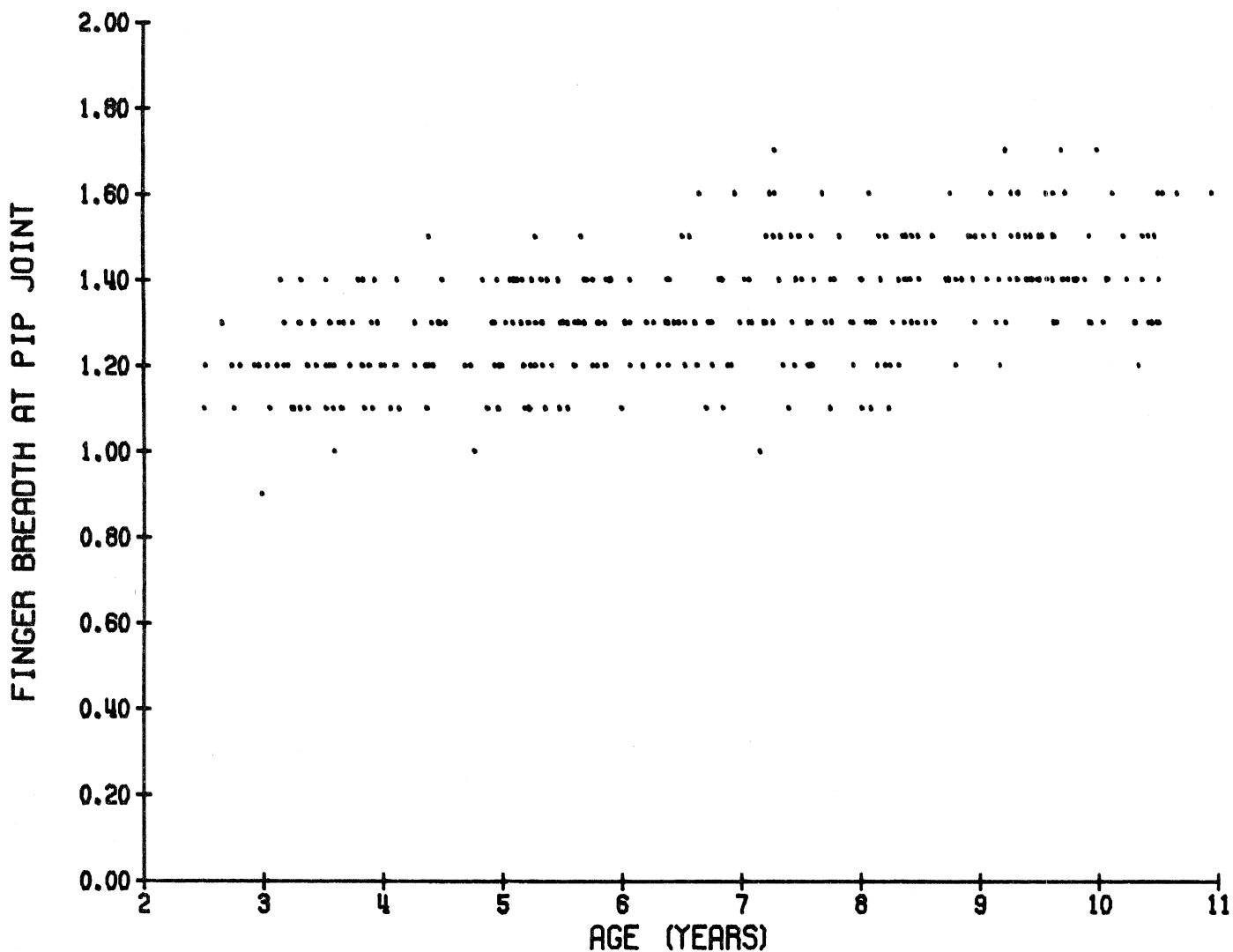
## FINGER BREADTH AT PROXIMAL INTERPHALANGEAL JOINT

DESCRIPTION: Measure the maximum width of the second finger at the second knuckle (proximal interphalangeal joint center of phalanx III).



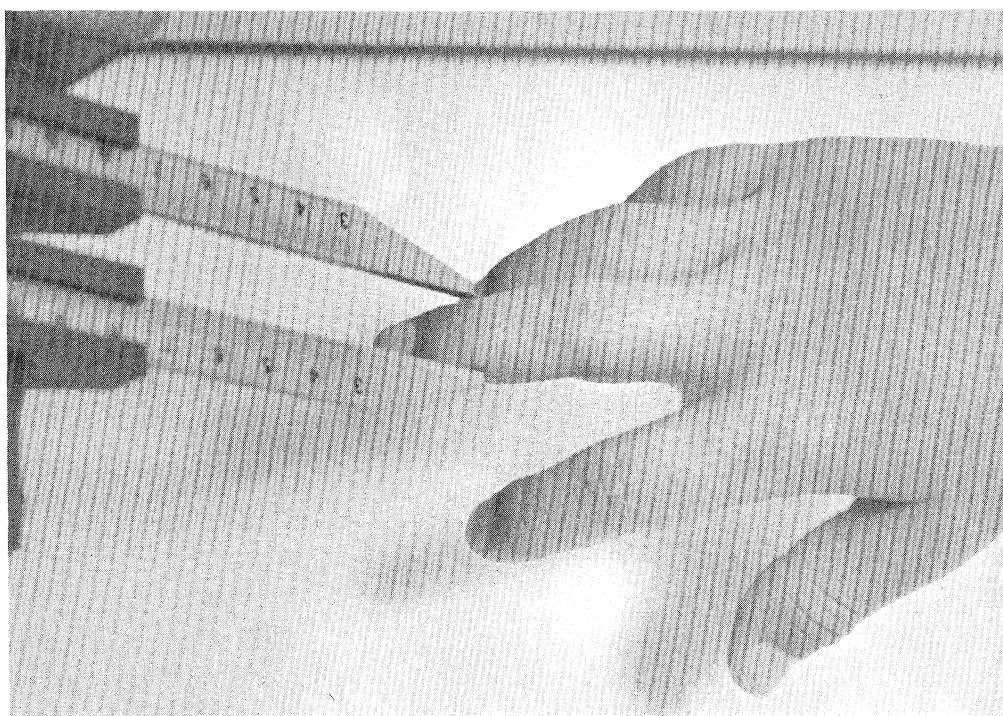
FINGER BREADTH-PROXIMAL INTERPHALANGEAL JOINT  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.2	0.1	0.9	0.9	1.2	1.3	1.4
3.5-4.5	45	1.2	0.1	1.0	1.0	1.2	1.4	1.5
4.5-5.5	44	1.3	0.1	1.0	1.0	1.2	1.4	1.5
5.5-6.5	48	1.3	0.1	1.1	1.1	1.2	1.4	1.5
6.5-7.5	46	1.3	0.2	1.0	1.0	1.3	1.6	1.7
7.5-8.5	52	1.3	0.1	1.1	1.1	1.3	1.5	1.6
8.5-9.5	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7
9.5-10.5	45	1.4	0.1	1.2	1.2	1.4	1.6	1.7



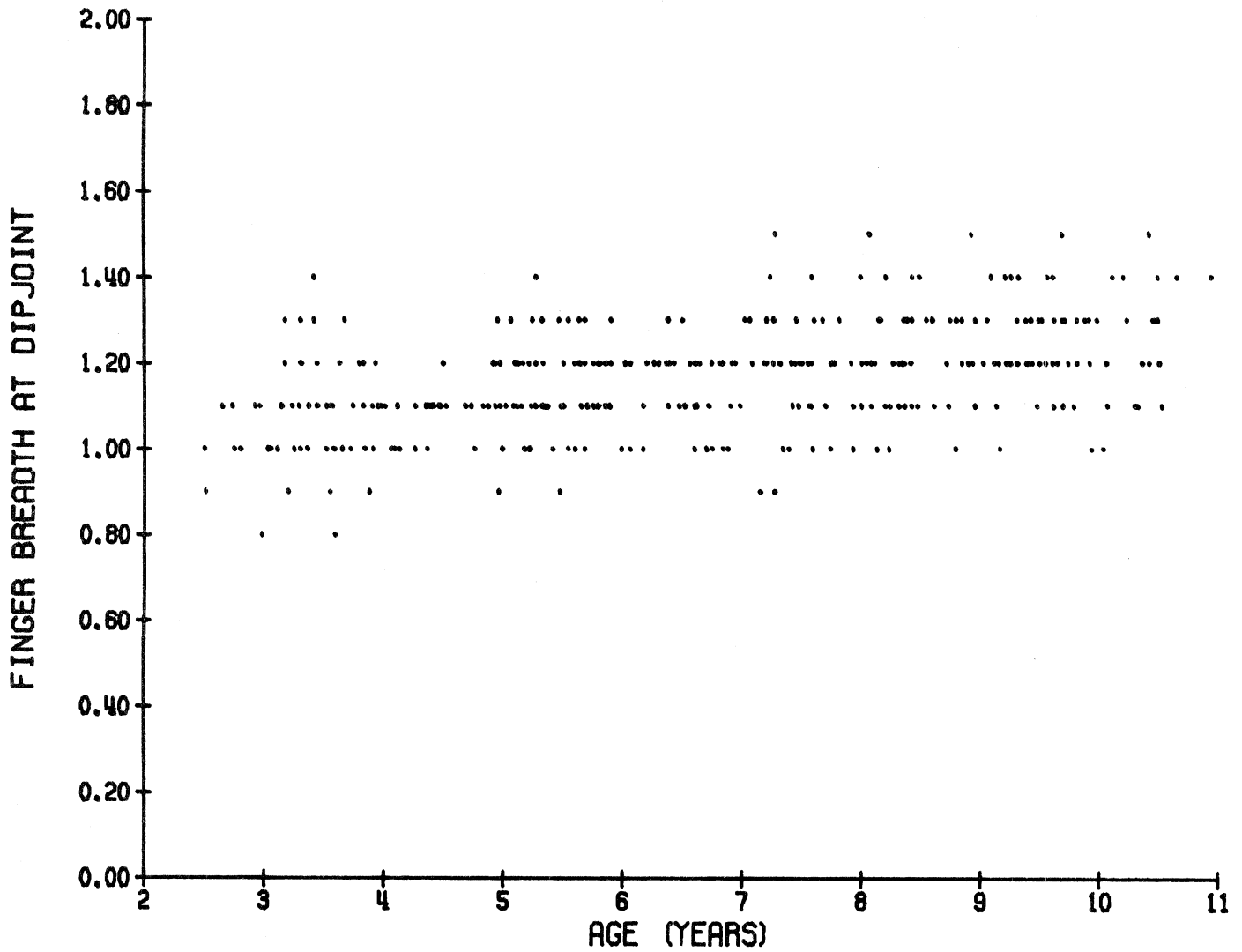
FINGER BREADTH AT DISTAL INTERPHALANGEAL JOINT

DESCRIPTION: Measure the maximum width of the second finger at the first knuckle (distal interphalangeal joint center of phalanx III).



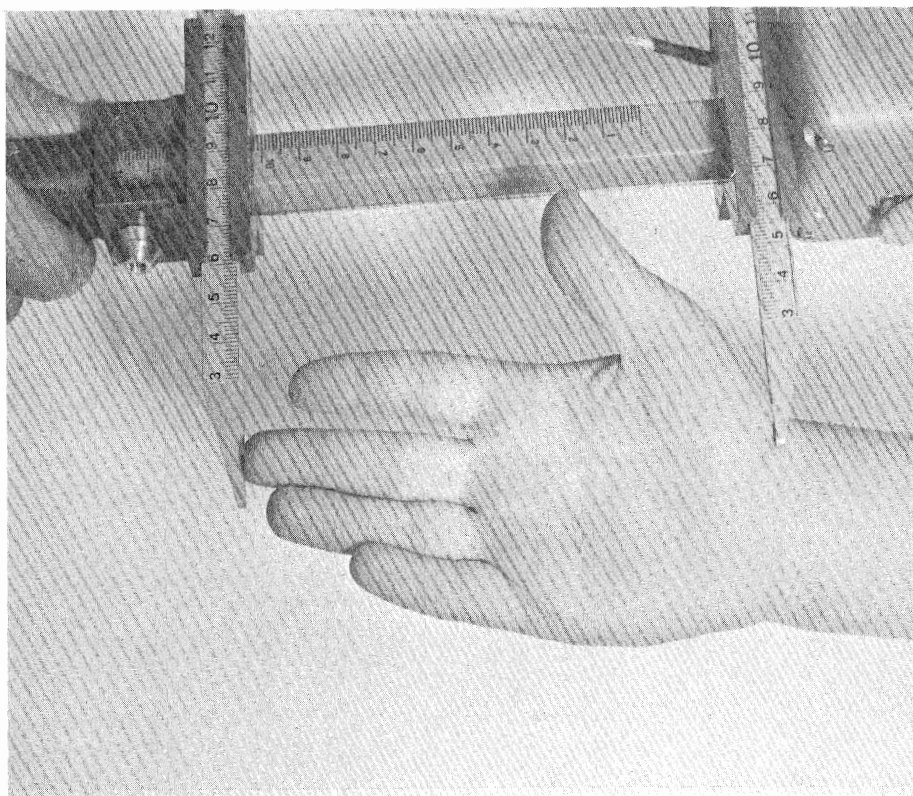
FINGER BREADTH-DISTAL INTERPHALANGEAL JOINT  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.1	0.1	0.8	0.8	1.0	1.3	1.4
3.5-4.5	45	1.1	0.1	0.8	0.9	1.0	1.2	1.3
4.5-5.5	44	1.1	0.1	0.9	0.9	1.1	1.3	1.4
5.5-6.5	49	1.2	0.1	1.0	1.0	1.1	1.3	1.3
6.5-7.5	46	1.2	0.1	0.9	0.9	1.1	1.3	1.5
7.5-8.5	51	1.2	0.1	1.0	1.0	1.1	1.4	1.5
8.5-9.5	42	1.2	0.1	1.0	1.0	1.2	1.4	1.5
9.5-10.5	45	1.2	0.1	1.0	1.0	1.2	1.4	1.5



## HAND LENGTH

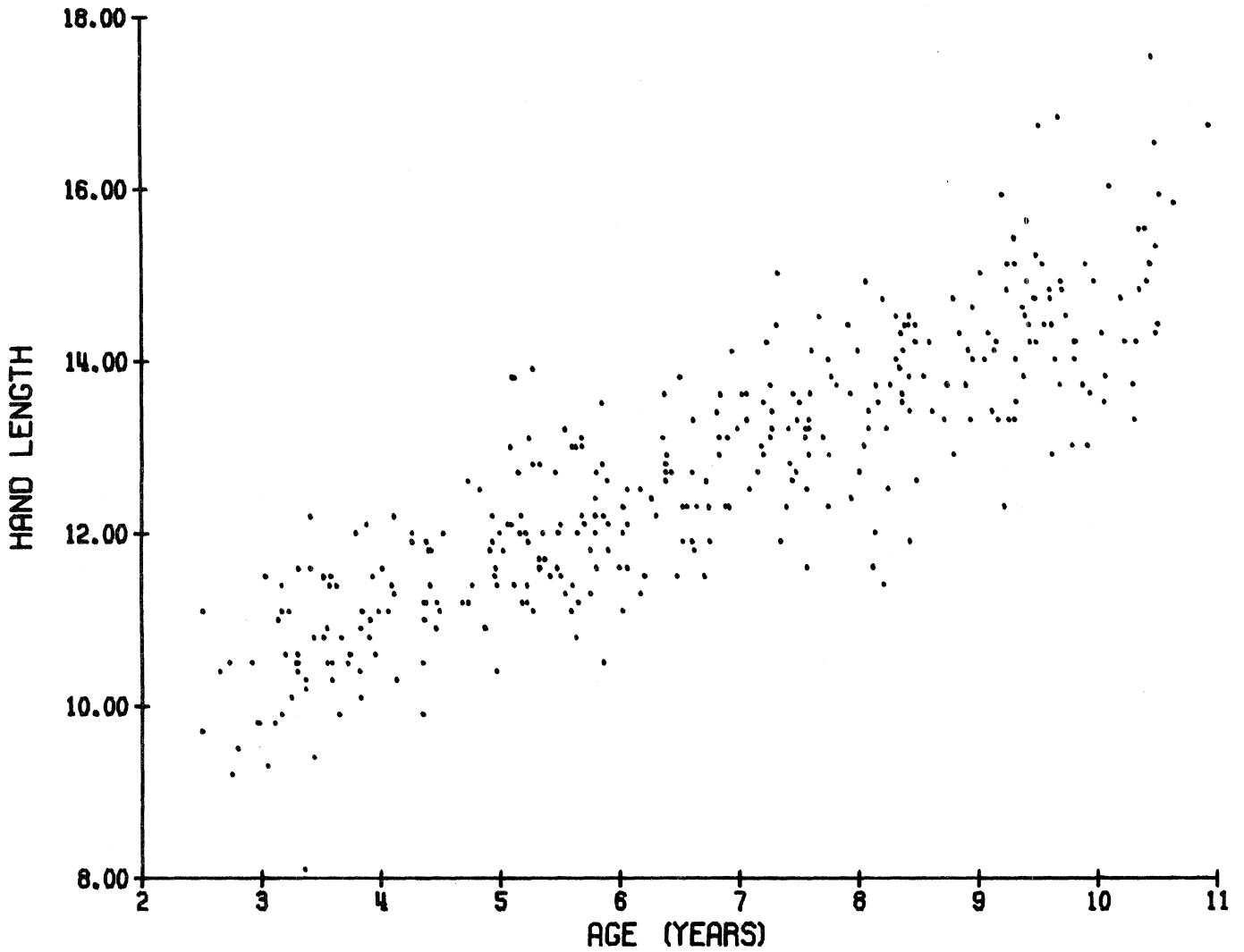
DESCRIPTION: Measure from the wrist (radiocarpal joint center) to the tip of the second finger (phalanx III). All fingers and thumb are fully adducted and extended.





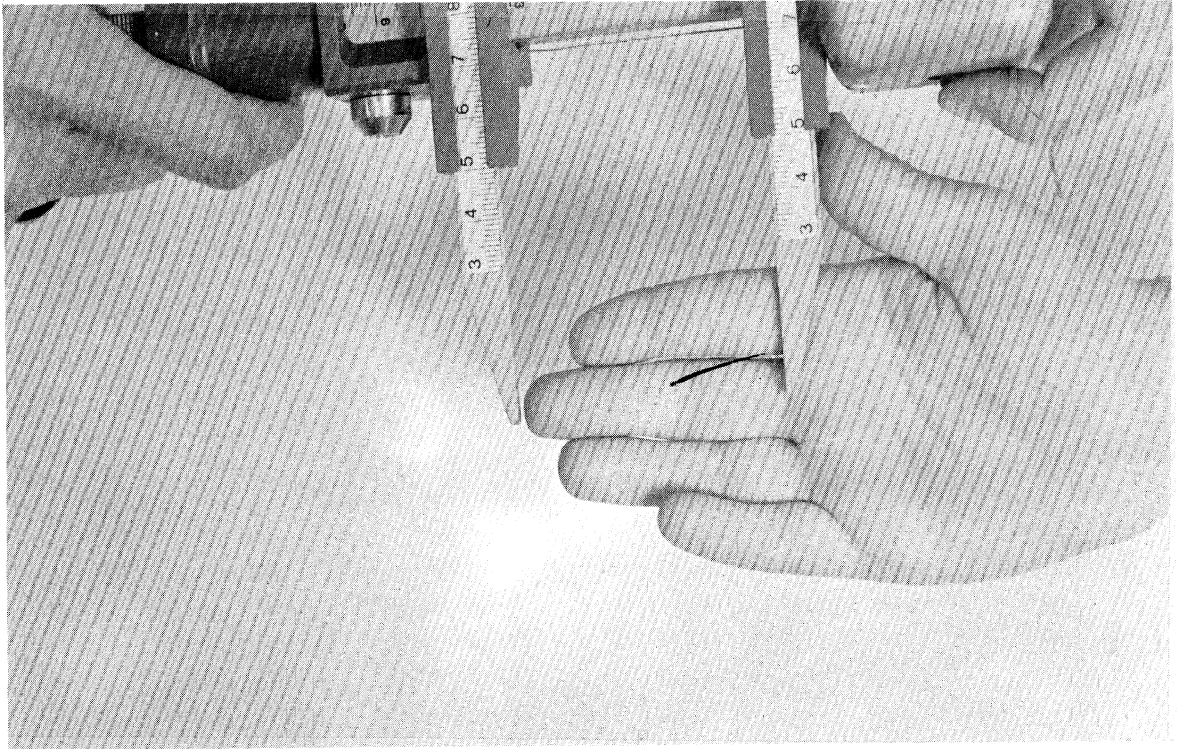
**HAND LENGTH LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	10.4	0.9	8.1	8.7	10.4	11.6	12.2
3.5-4.5	45	11.1	0.6	9.9	9.9	11.0	12.0	12.2
4.5-5.5	44	12.0	0.8	10.4	10.9	11.8	13.4	13.9
5.5-6.5	49	12.2	0.7	10.5	10.9	12.1	13.2	13.6
6.5-7.5	46	12.9	0.8	11.5	11.8	12.9	14.2	15.0
7.5-8.5	52	13.4	0.9	11.4	11.6	13.5	14.5	14.9
8.5-9.5	42	14.2	0.8	12.3	12.9	14.1	15.4	15.9
9.5-10.5	45	14.7	1.1	12.9	13.0	14.5	16.7	17.5



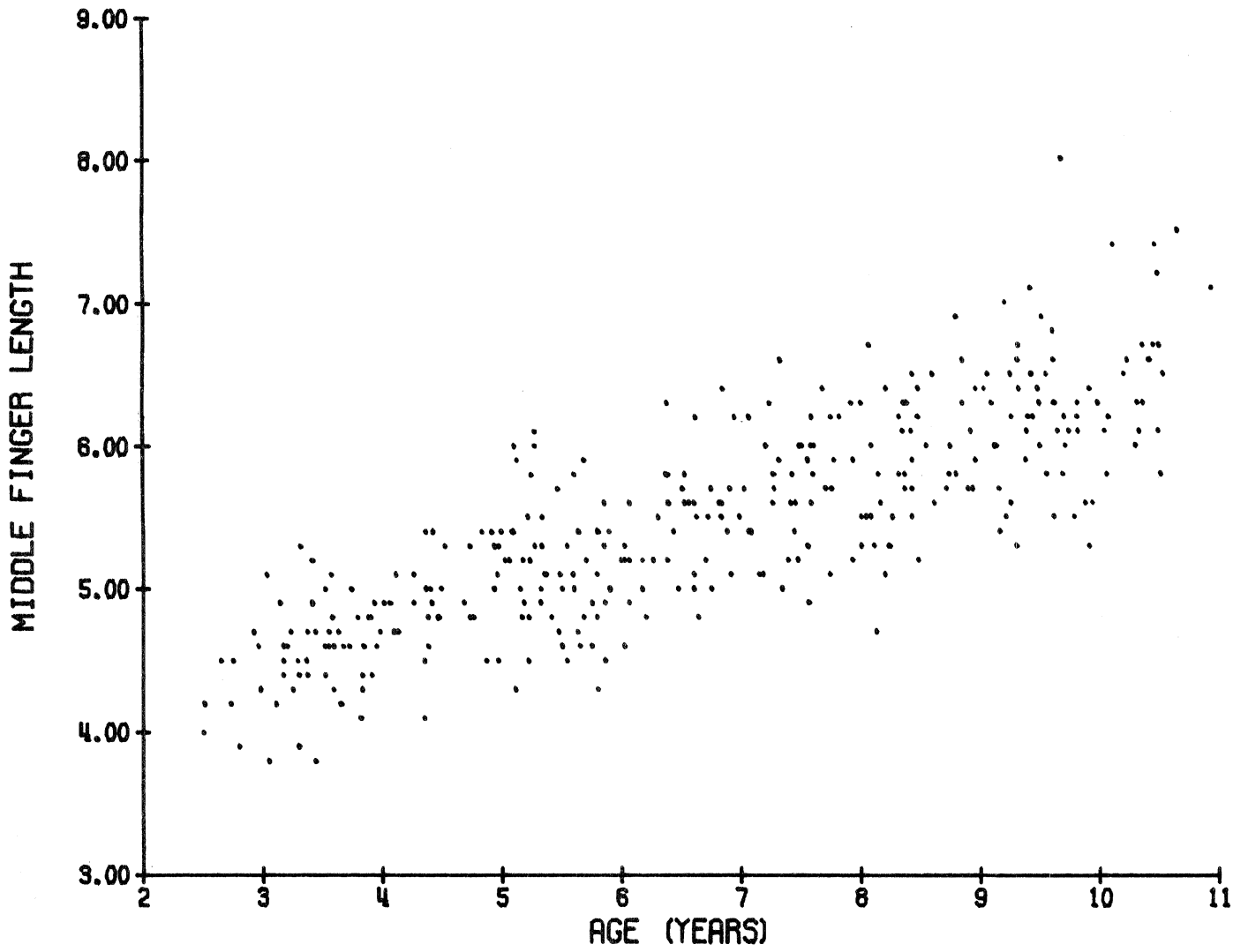
## MIDDLE FINGER LENGTH

DESCRIPTION: Measure from the palmer skinfold of the second finger (phalanx III) to the tip of the second finger (phalanx III).



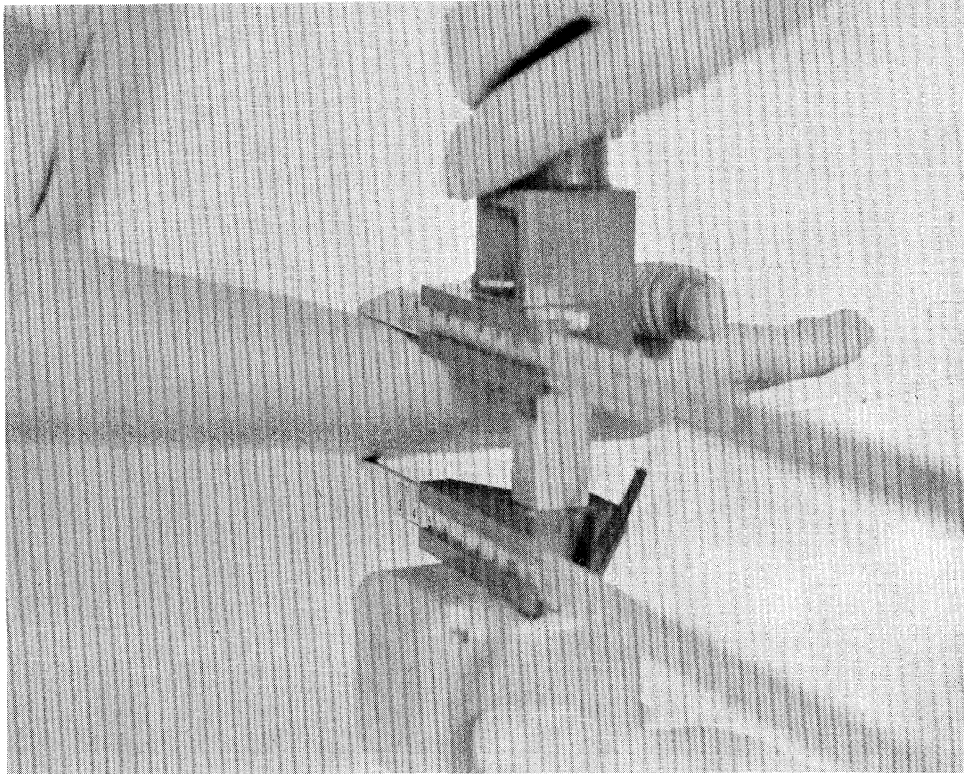
MIDDLE FINGER LENGTH (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	4.5	0.4	3.8	3.8	4.4	5.1	5.3
3.5-4.5	45	4.7	0.3	4.1	4.1	4.7	5.1	5.4
4.5-5.5	43	5.2	0.4	4.3	4.4	5.1	5.9	6.1
5.5-6.5	49	5.2	0.4	4.3	4.4	5.1	5.8	6.3
6.5-7.5	46	5.6	0.4	4.8	4.9	5.5	6.3	6.6
7.5-8.5	52	5.8	0.5	4.7	5.0	5.8	6.4	6.7
8.5-9.5	42	6.2	0.4	5.3	5.4	6.1	6.9	7.1
9.5-10.5	45	6.4	0.6	5.3	5.4	6.2	7.4	8.0



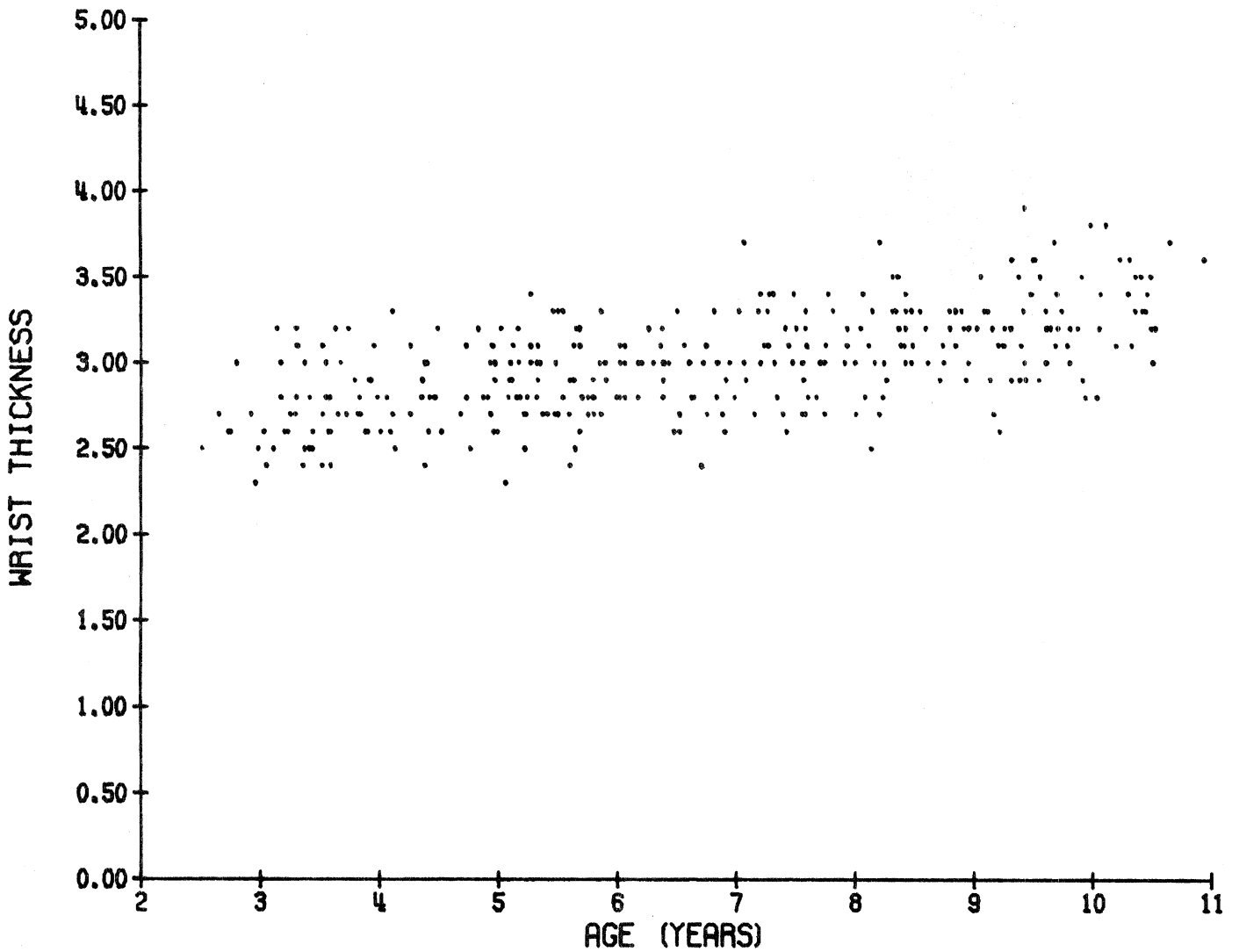
## WRIST THICKNESS

DESCRIPTION: Measure the maximum thickness of the wrist (radiocarpal joint center) at the distal end of the radius.



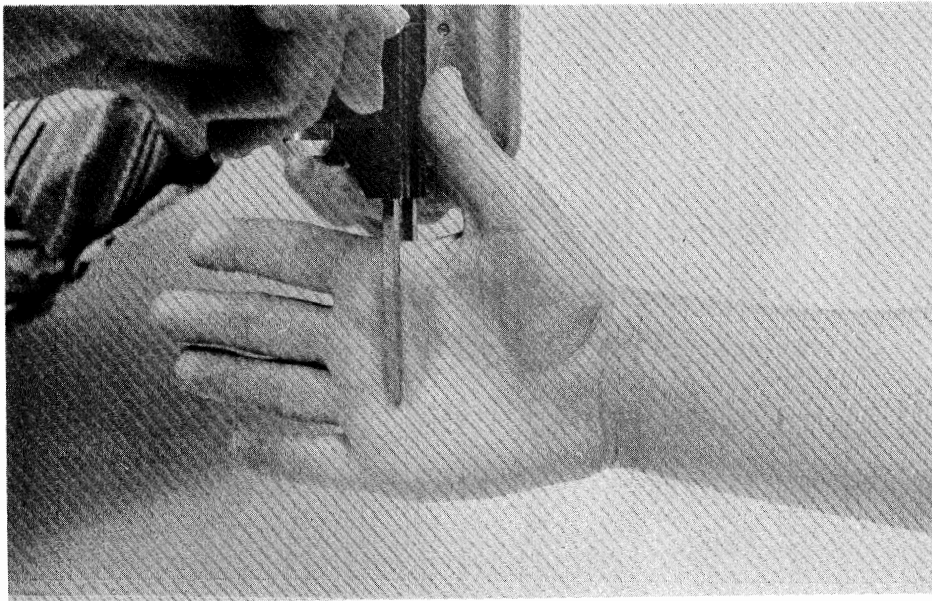
WRIST THICKNESS (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	30	2.7	0.2	2.3	2.3	2.6	3.1	3.2
3.5-4.5	45	2.8	0.2	2.4	2.4	2.7	3.2	3.3
4.5-5.5	44	2.9	0.2	2.3	2.4	2.8	3.2	3.4
5.5-6.5	49	2.9	0.2	2.4	2.5	2.9	3.2	3.3
6.5-7.5	45	3.0	0.3	2.4	2.5	3.0	3.4	3.7
7.5-8.5	52	3.1	0.3	2.5	2.6	3.0	3.4	3.7
8.5-9.5	42	3.2	0.2	2.6	2.7	3.1	3.5	3.9
9.5-10.5	45	3.3	0.3	2.8	2.8	3.2	3.7	3.8



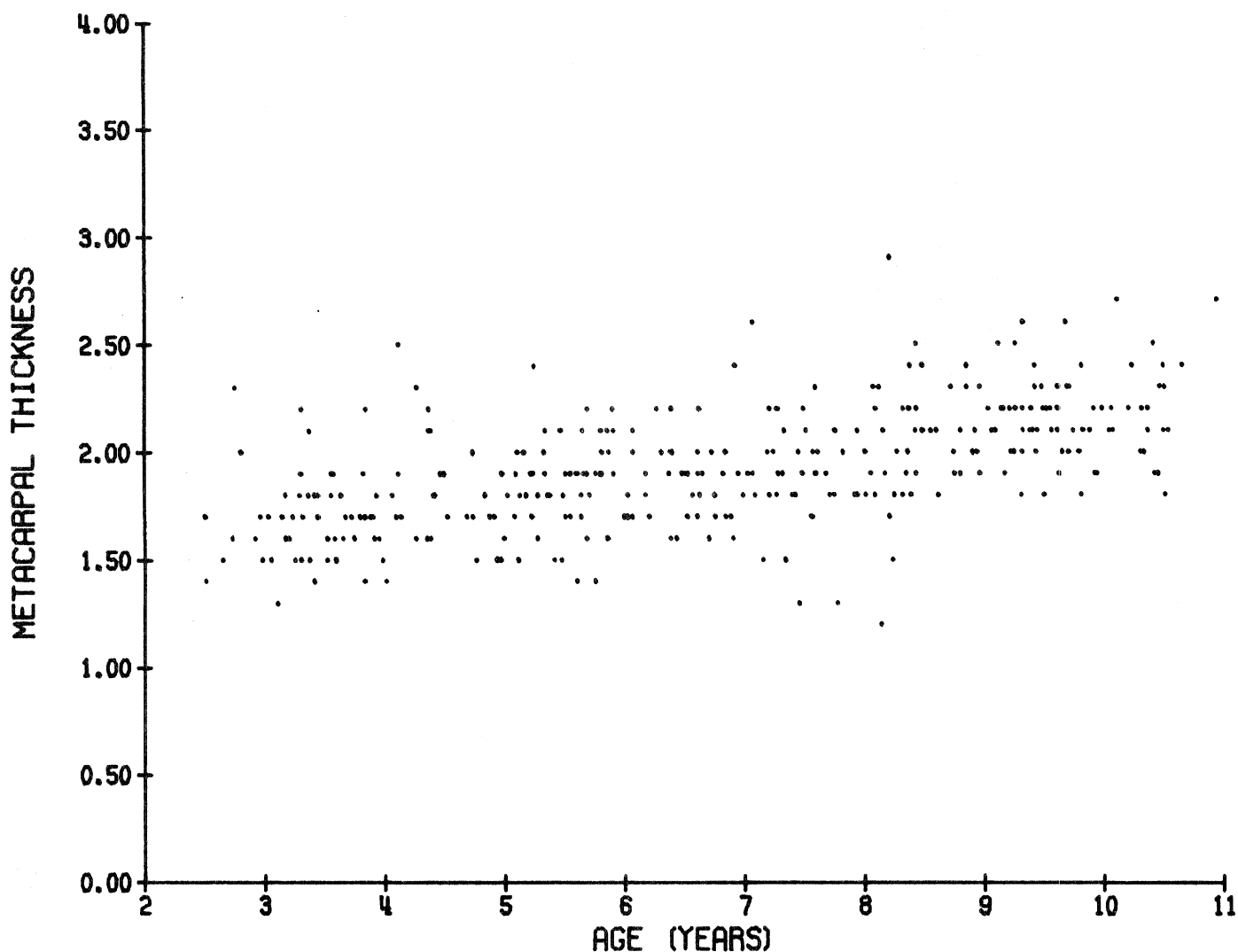
METACARPAL PHALANGEAL JOINT THICKNESS

DESCRIPTION: Measure the maximum thickness of the third knuckle of the second finger (metacarpal phalangeal joint of phalanx III).



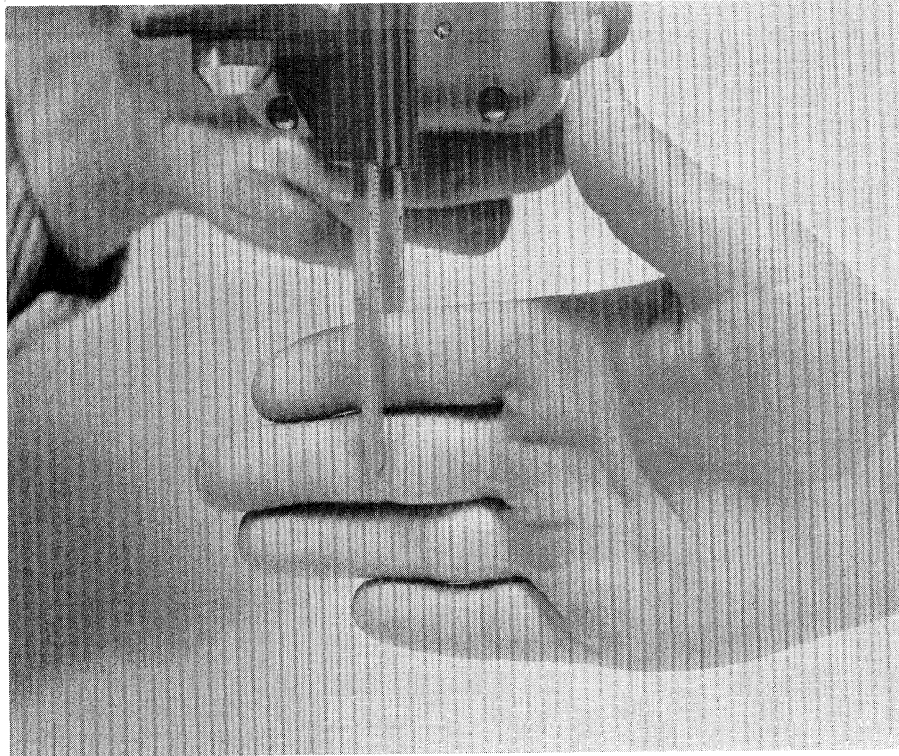
METACARPAL THICKNESS (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.7	0.2	1.3	1.3	1.6	2.1	2.3
3.5-4.5	45	1.8	0.2	1.4	1.4	1.7	2.2	2.5
4.5-5.5	42	1.8	0.2	1.5	1.5	1.7	2.0	2.4
5.5-6.5	49	1.9	0.2	1.4	1.4	1.8	2.1	2.2
6.5-7.5	46	1.9	0.2	1.3	1.4	1.8	2.2	2.6
7.5-8.5	52	2.0	0.3	1.2	1.4	1.9	2.4	2.9
8.5-9.5	42	2.1	0.2	1.8	1.8	2.1	2.4	2.6
9.5-10.5	45	2.2	0.2	1.8	1.8	2.1	2.6	2.7



PROXIMAL INTERPHALANGEAL JOINT THICKNESS

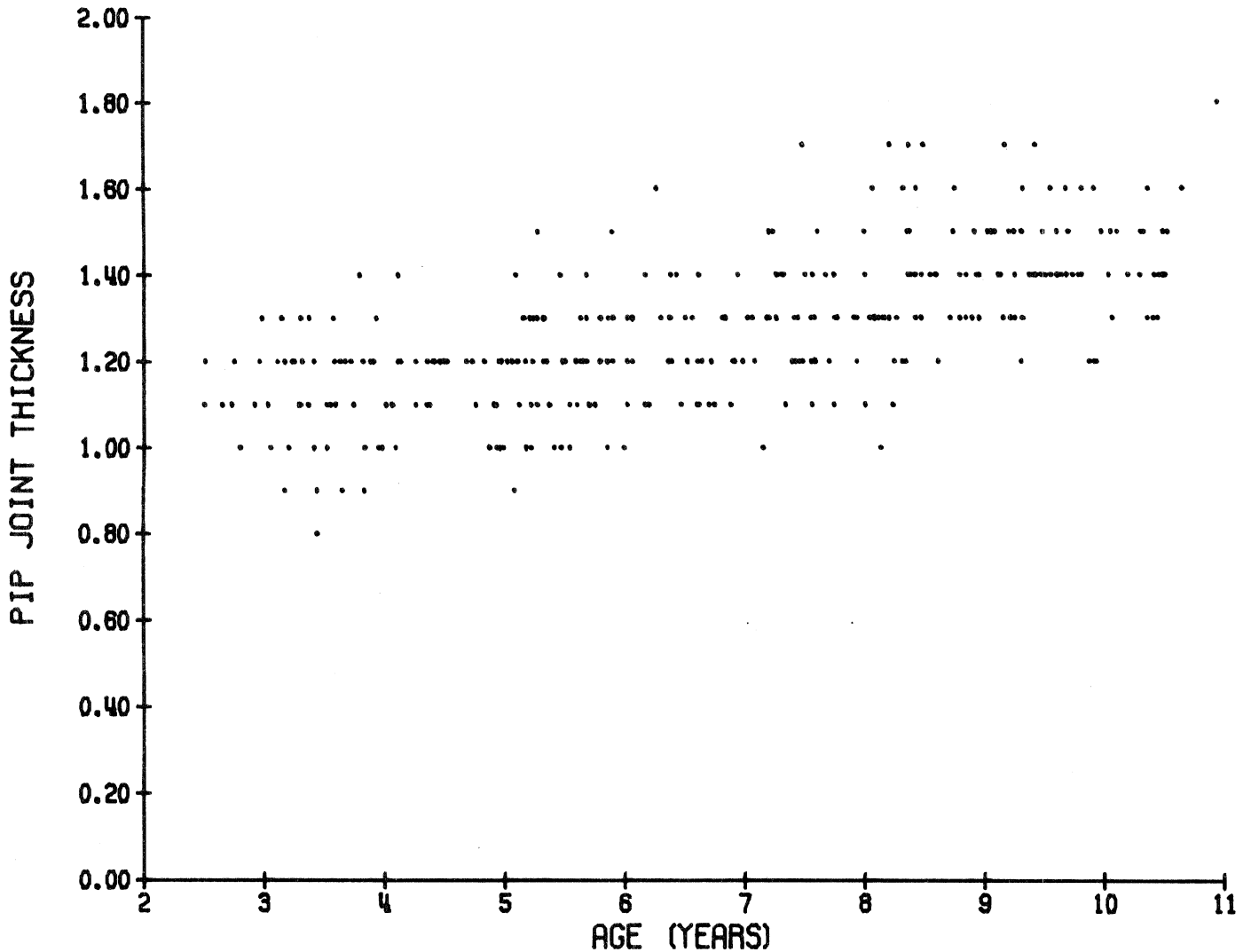
DESCRIPTION: Measure the maximum thickness of the second knuckle of the second finger (proximal interphalangeal joint of phalanx III).





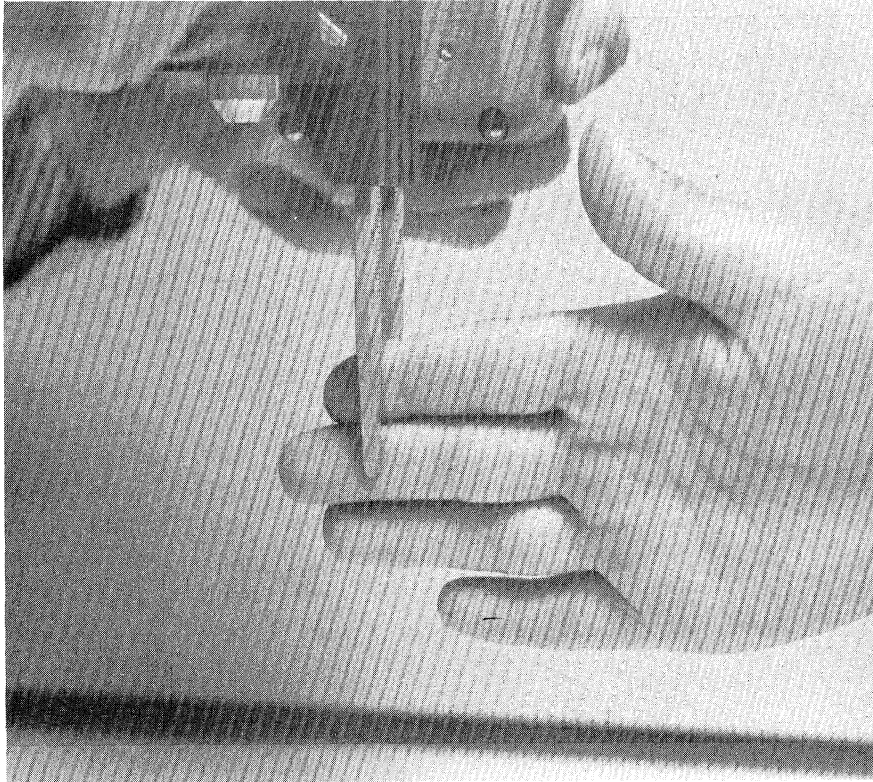
PROXIMAL INTERPHALANGEAL JOINT THICKNESS (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.1	0.1	0.8	0.8	1.1	1.3	1.3
3.5-4.5	45	1.1	0.1	0.9	0.9	1.1	1.3	1.4
4.5-5.5	44	1.2	0.1	0.9	0.9	1.1	1.3	1.5
5.5-6.5	48	1.2	0.1	1.0	1.0	1.2	1.4	1.6
6.5-7.5	45	1.3	0.1	1.0	1.0	1.2	1.4	1.7
7.5-8.5	51	1.3	0.2	1.0	1.0	1.3	1.6	1.7
8.5-9.5	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7
9.5-10.5	44	1.4	0.1	1.2	1.2	1.4	1.6	1.8



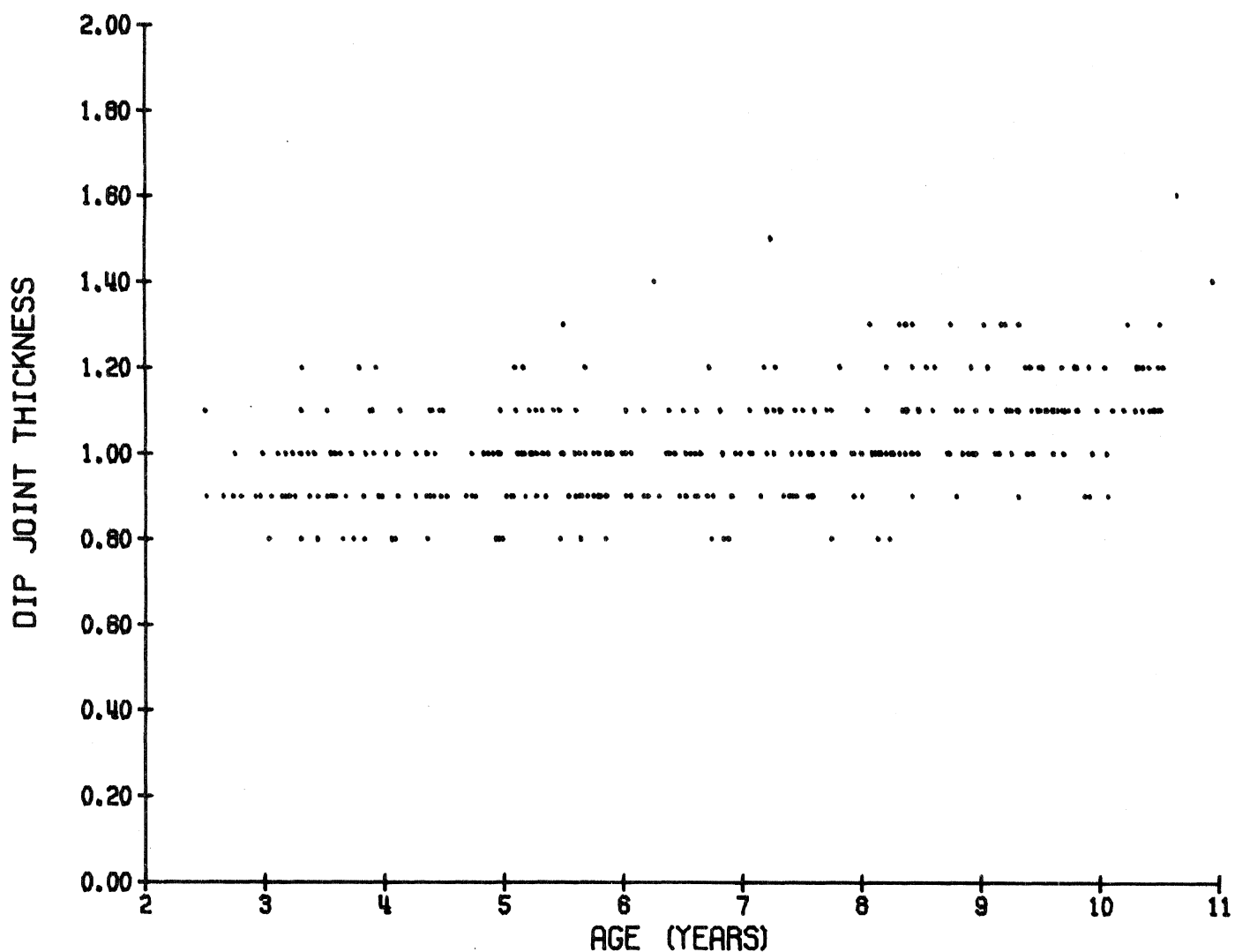
DISTAL INTERPHALANGEAL JOINT THICKNESS

DESCRIPTION: Measure the maximum thickness of the first knuckle of the second finger (distal interphalangeal joint of phalanx III),



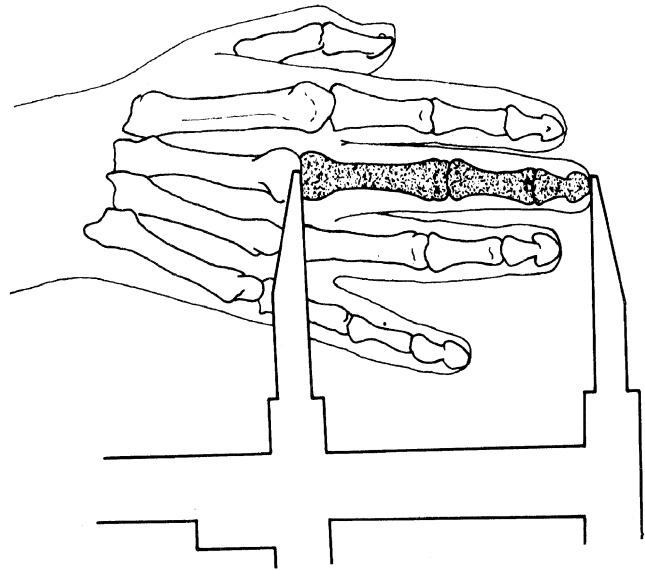
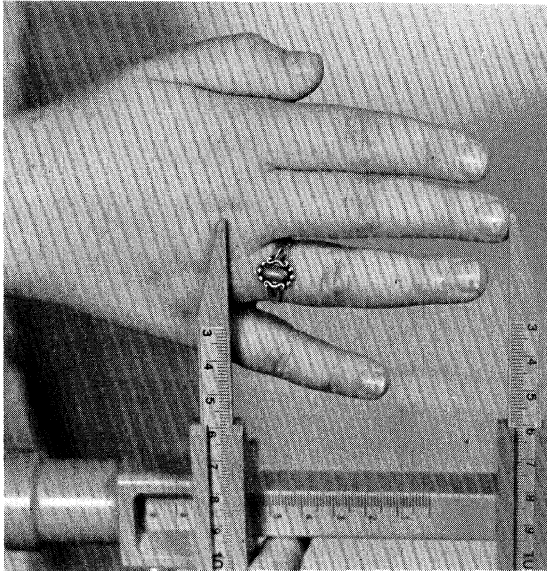
DISTAL INTERPHALANGEAL JOINT THICKNESS (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	0.9	0.1	0.8	0.8	0.9	1.1	1.2
3.5-4.5	45	1.0	0.1	0.8	0.8	0.9	1.1	1.2
4.5-5.5	44	1.0	0.1	0.8	0.8	0.9	1.1	1.2
5.5-6.5	49	1.0	0.1	0.8	0.8	0.9	1.2	1.4
6.5-7.5	43	1.0	0.1	0.8	0.8	0.9	1.2	1.5
7.5-8.5	52	1.0	0.1	0.8	0.8	1.0	1.2	1.3
8.5-9.5	42	1.1	0.1	0.9	0.9	1.0	1.3	1.3
9.5-10.5	45	1.1	0.1	0.9	0.9	1.1	1.3	1.6



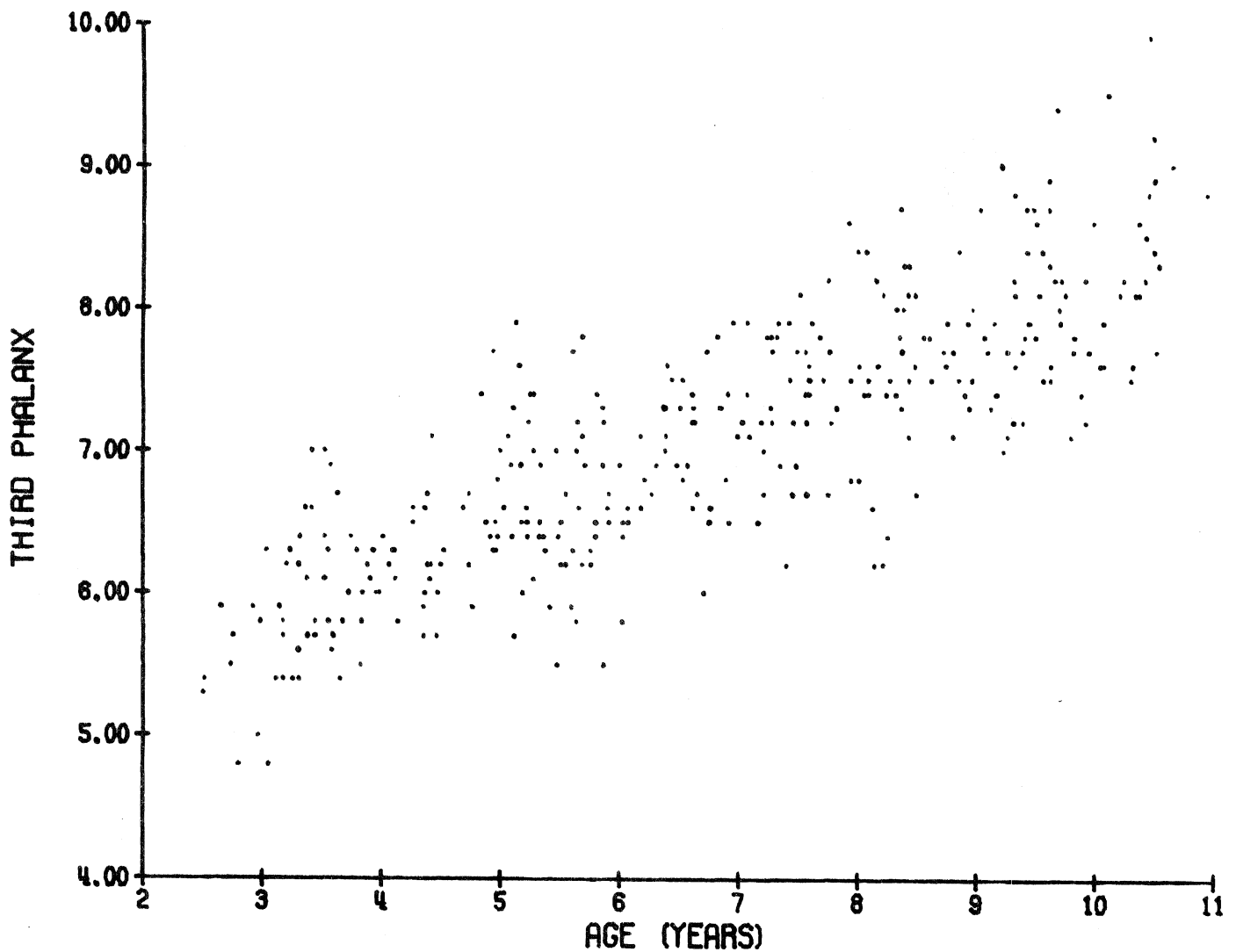
### THIRD PHALANX

DESCRIPTION: Measure from the third knuckle (third carpophalangeal joint center) to the finger tip (distal end of the third phalanx).



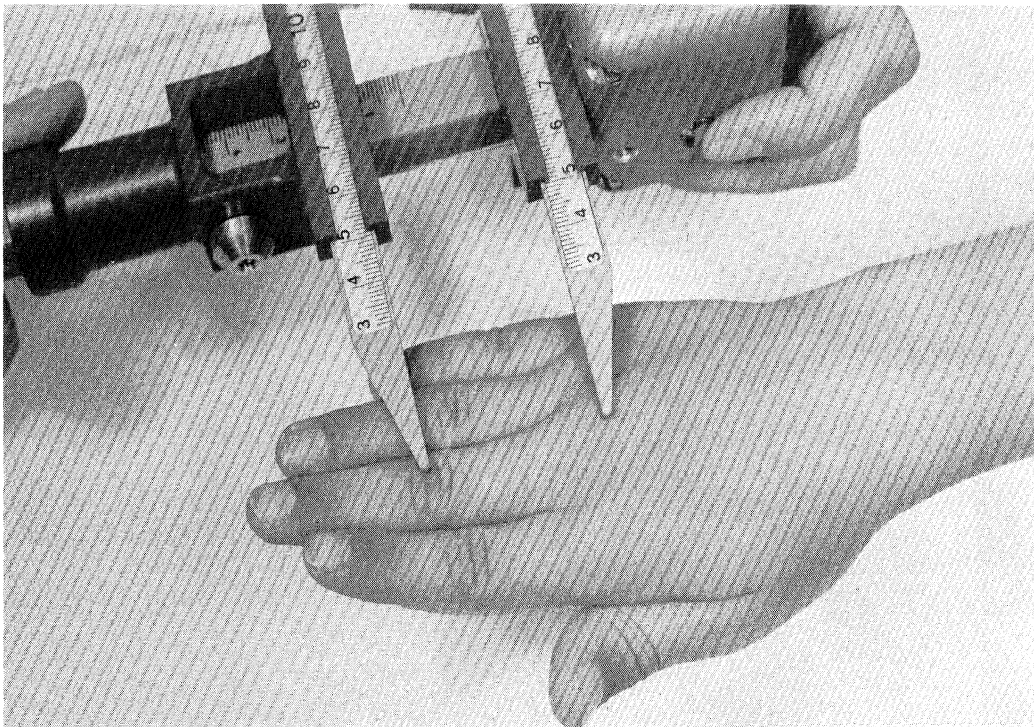
**THIRD PHALANX LINKAGE (cm)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	5.8	0.5	4.8	4.8	5.7	6.5	7.0
3.5-4.5	45	6.1	0.4	5.4	5.5	6.1	6.8	7.1
4.5-5.5	44	6.7	0.5	5.5	5.7	6.5	7.6	7.9
5.5-6.5	49	6.7	0.5	5.5	5.7	6.6	7.6	7.8
6.5-7.5	46	7.2	0.5	6.0	6.2	7.2	7.8	7.9
7.5-8.5	52	7.5	0.6	6.2	6.3	7.5	8.4	8.7
8.5-9.5	42	7.8	0.5	7.0	7.1	7.7	8.7	9.0
9.5-10.5	45	8.2	0.6	7.1	7.2	8.1	9.3	9.9



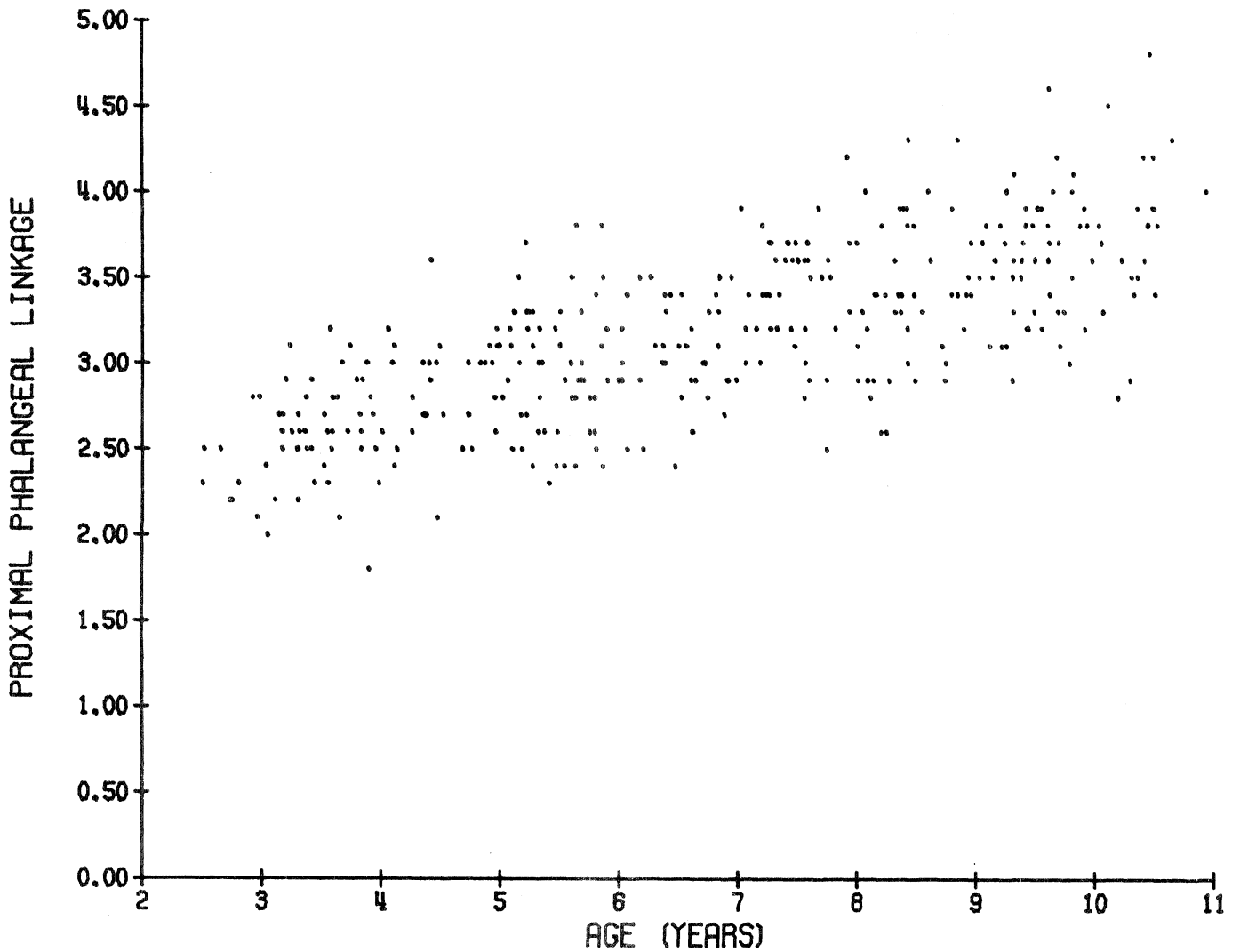
### PROXIMAL PHALANGEAL LINKAGE

DESCRIPTION: Measure from the tip of the second finger (phalanx III) to the third knuckle of the second finger (metacarpal-phalangeal joint center of phalanx III) with the finger fully extended.



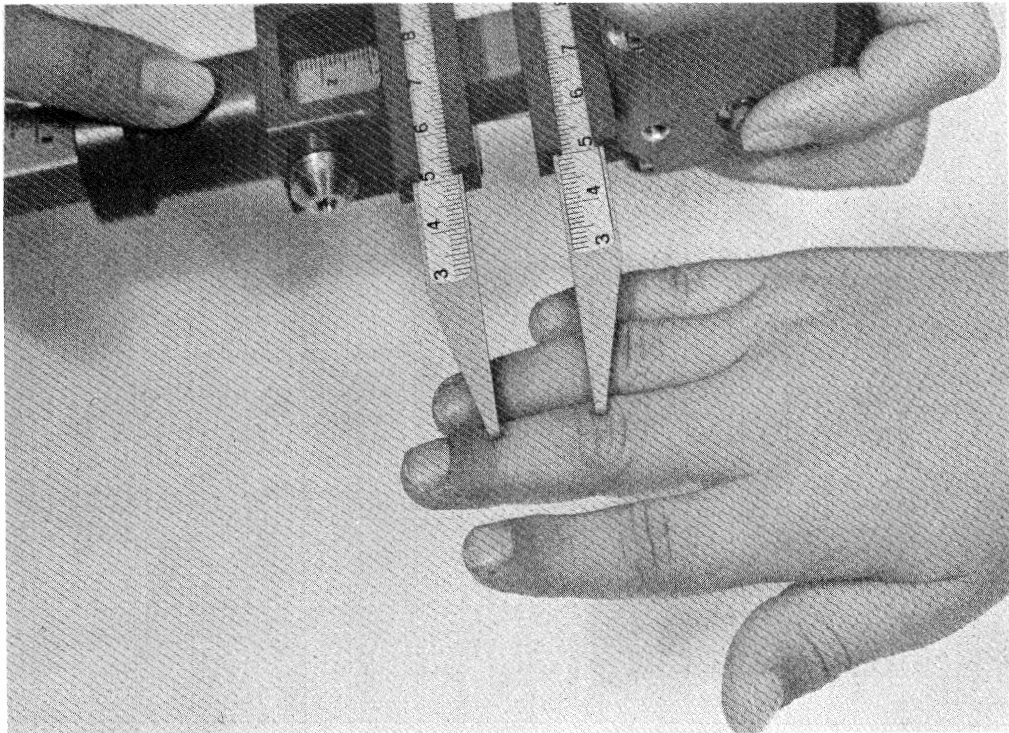
PROXIMAL PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	2.5	0.3	2.0	2.1	2.5	2.9	3.1
3.5-4.5	45	2.7	0.3	1.8	2.0	2.7	3.1	3.6
4.5-5.5	43	2.9	0.3	2.3	2.4	2.9	3.3	3.7
5.5-6.5	49	3.0	0.4	2.4	2.4	2.9	3.5	3.8
6.5-7.5	46	3.2	0.3	2.6	2.6	3.2	3.7	3.9
7.5-8.5	52	3.4	0.4	2.5	2.6	3.3	3.9	4.3
8.5-9.5	42	3.5	0.3	2.9	2.9	3.5	4.0	4.3
9.5-10.5	45	3.7	0.4	2.8	2.9	3.7	4.4	4.8



## MIDDLE PHALANGEAL LINKAGE

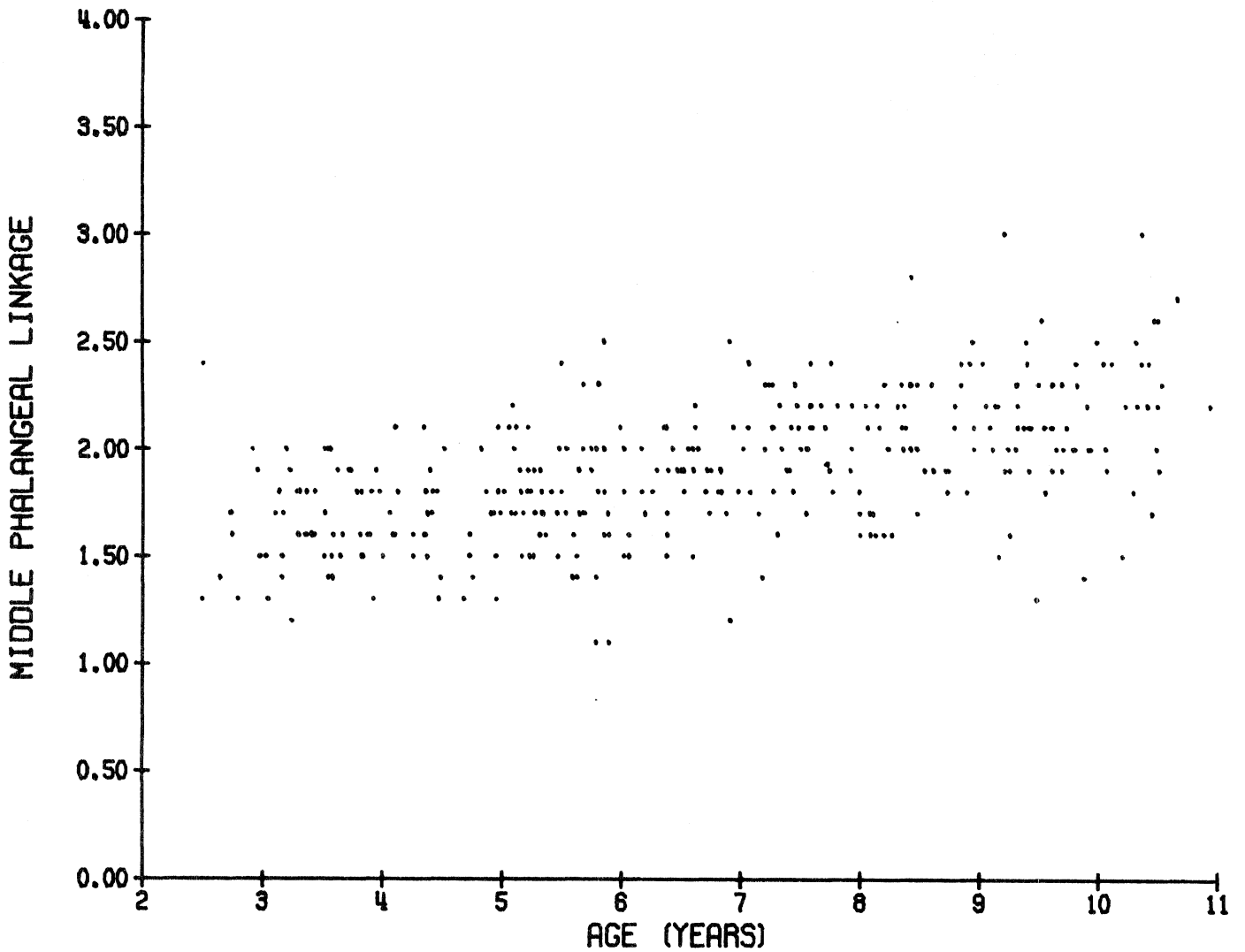
DESCRIPTION: Measure from the first knuckle of the second finger (distal interphalangeal joint center of phalanx III) to the second knuckle of the second finger (proximal interphalangeal joint center of phalanx III) with the finger fully extended.





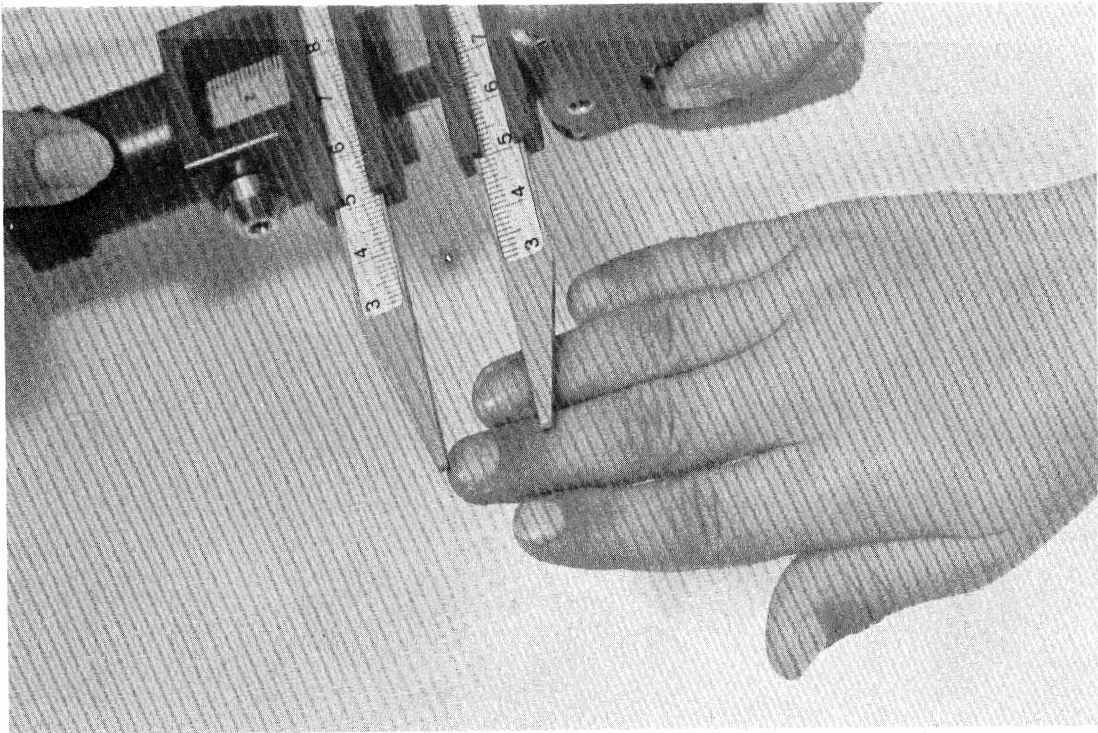
MIDDLE PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.6	0.2	1.2	1.2	1.6	2.0	2.4
3.5-4.5	45	1.7	0.2	1.3	1.3	1.6	2.0	2.1
4.5-5.5	43	1.8	0.2	1.3	1.3	1.7	2.1	2.2
5.5-6.5	49	1.8	0.3	1.1	1.1	1.7	2.3	2.5
6.5-7.5	46	1.9	0.3	1.2	1.4	1.9	2.3	2.5
7.5-8.5	52	2.0	0.3	1.6	1.6	2.0	2.3	2.8
8.5-9.5	42	2.1	0.3	1.3	1.5	2.1	2.4	3.0
9.5-10.5	44	2.2	0.3	1.4	1.5	2.1	2.6	3.0



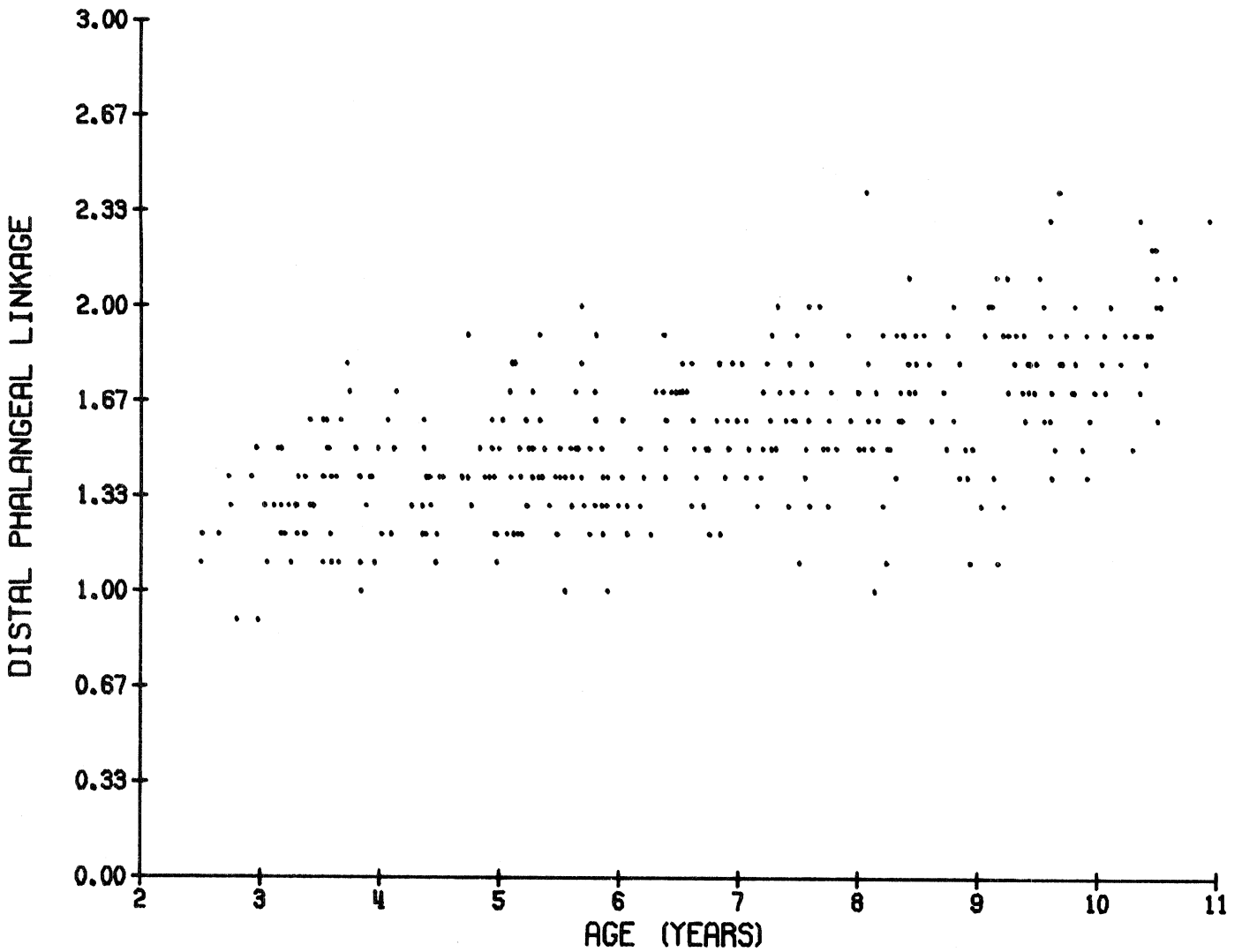
DISTAL PHALANGEAL LINKAGE

DESCRIPTION: Measure from the tip of the second finger (phalanx III) to the first knuckle of the second finger (distal interphalangeal joint center of phalanx III) with the finger fully extended.



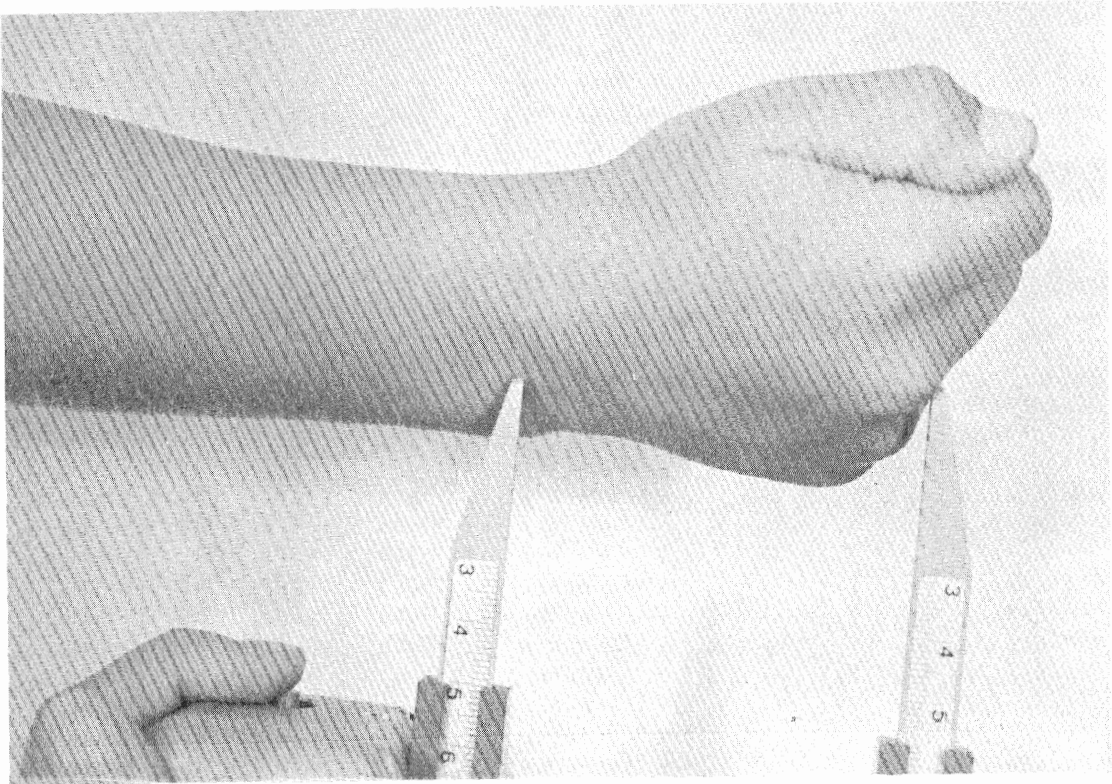
DISTAL PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.3	0.2	0.9	0.9	1.2	1.5	1.6
3.5-4.5	44	1.4	0.2	1.0	1.0	1.3	1.6	1.8
4.5-5.5	44	1.4	0.2	1.1	1.1	1.4	1.8	1.9
5.5-6.5	49	1.5	0.2	1.0	1.0	1.4	1.8	2.0
6.5-7.5	46	1.6	0.2	1.2	1.2	1.5	1.8	2.0
7.5-8.5	52	1.6	0.3	1.0	1.1	1.6	2.0	2.4
8.5-9.5	42	1.7	0.2	1.1	1.1	1.7	2.0	2.1
9.5-10.5	45	1.9	0.2	1.4	1.4	1.8	2.3	2.4



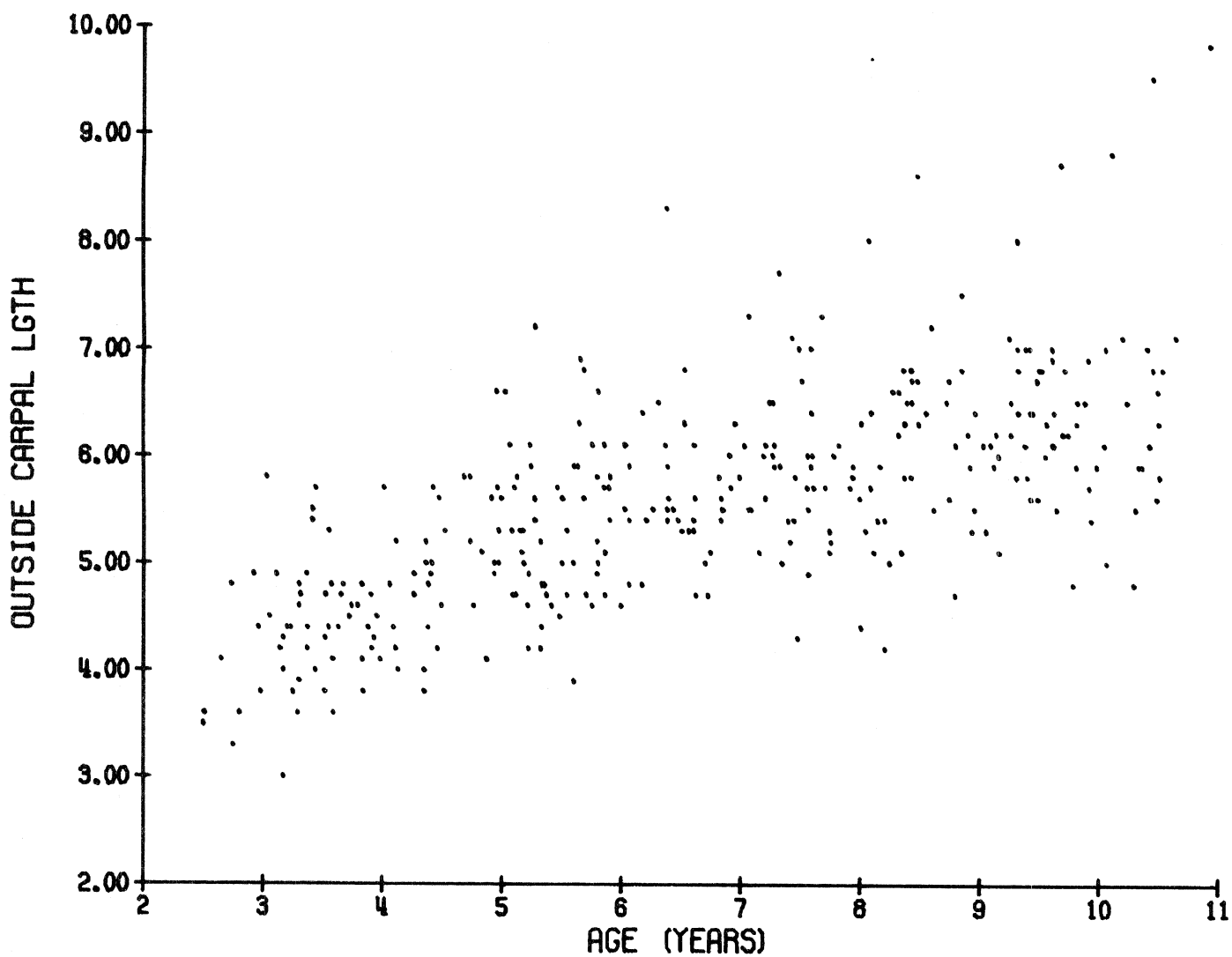
## OUTSIDE CARPAL LINKAGE

DESCRIPTION: Measure from the outside of the third knuckle of the second finger (metacarpal phalangeal joint of phalanx III) to the wrist (radiocarpal joint center) with the hand held in a fist and the wrist fully flexed.



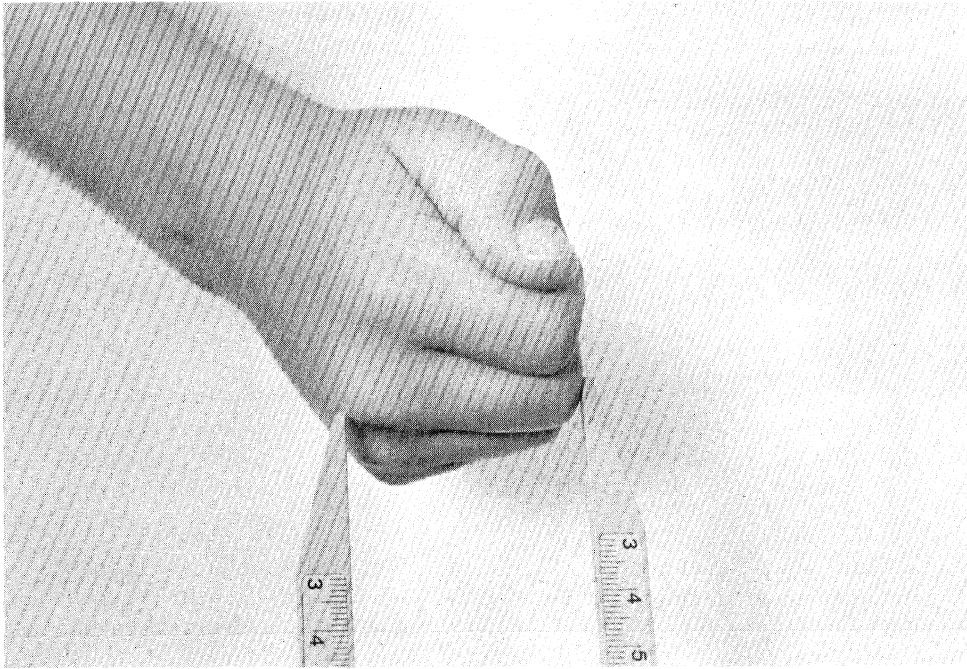
OUTSIDE CARPAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	4.4	0.7	3.0	3.2	4.3	5.6	5.8
3.5-4.5	45	4.6	0.5	3.6	3.7	4.5	5.5	5.7
4.5-5.5	43	5.3	0.7	4.1	4.2	5.2	6.3	7.2
5.5-6.5	49	5.6	0.7	3.9	4.4	5.5	6.7	8.3
6.5-7.5	43	5.8	0.7	4.3	4.5	5.6	7.1	7.7
7.5-8.5	50	6.0	0.8	4.2	4.6	5.9	7.2	8.6
8.5-9.5	40	6.3	0.7	4.7	5.1	6.2	7.2	8.0
9.5-10.5	44	6.5	1.1	4.8	4.8	6.2	8.8	9.8



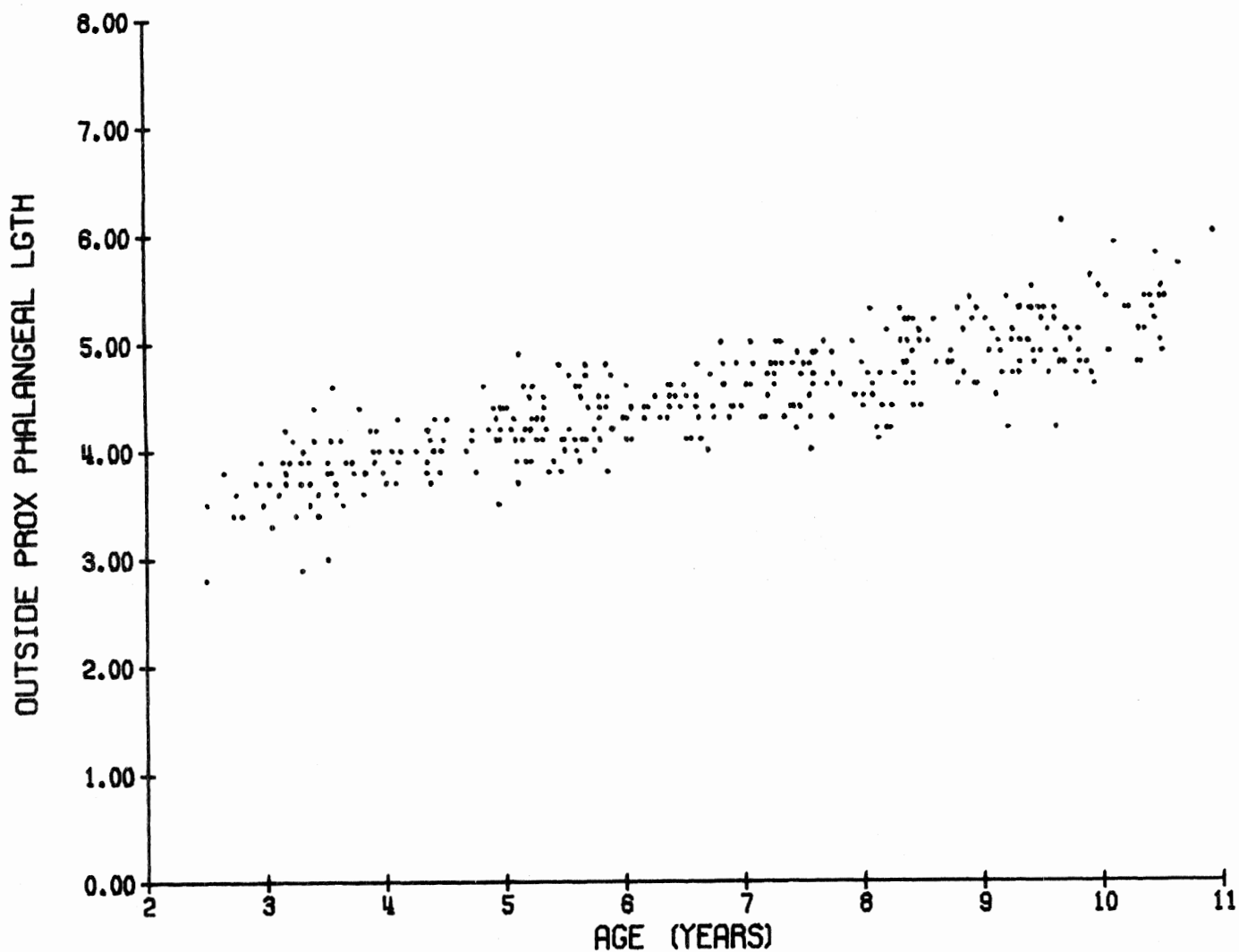
## OUTSIDE PROXIMAL PHALANGEAL LINKAGE

DESCRIPTION: Measure from the outside of the second knuckle of the second finger (proximal interphalangeal joint of phalanx III) to the outside of the third knuckle of the second finger (metacarpal phalangeal joint of phalanx III) with the hand held in a fist.



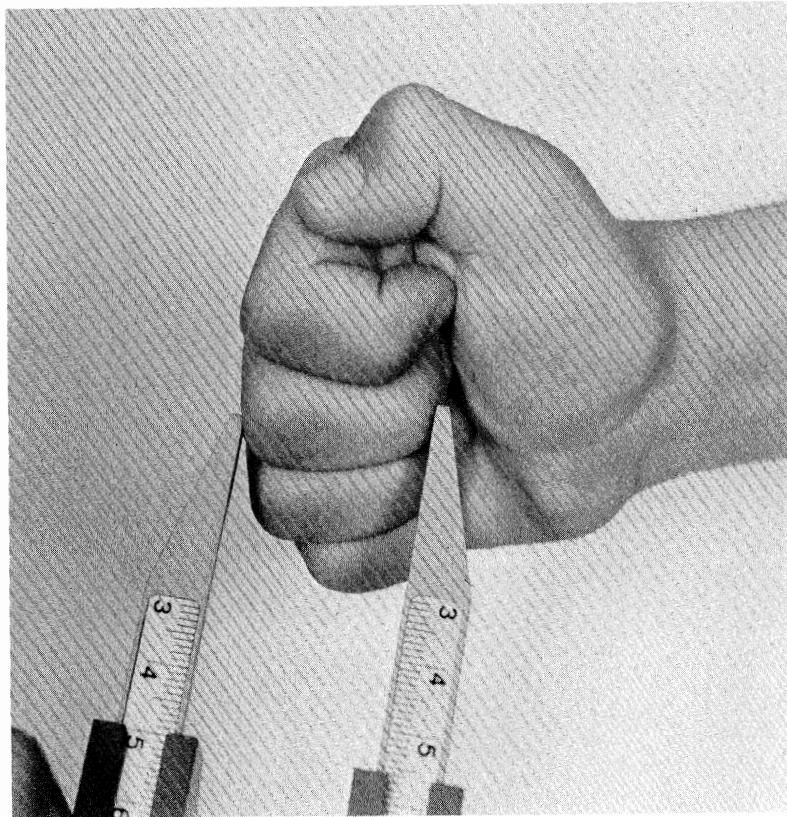
OUTSIDE PROXIMAL PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	3.7	0.3	2.8	2.9	3.6	4.1	4.4
3.5-4.5	45	3.9	0.3	3.0	3.5	3.9	4.3	4.6
4.5-5.5	44	4.2	0.3	3.5	3.7	4.2	4.6	4.9
5.5-6.5	49	4.4	0.2	3.8	3.9	4.3	4.7	4.8
6.5-7.5	46	4.5	0.3	4.0	4.0	4.5	4.9	5.0
7.5-8.5	51	4.7	0.3	4.0	4.1	4.6	5.2	5.3
8.5-9.5	42	5.0	0.3	4.2	4.5	4.9	5.3	5.5
9.5-10.5	45	5.2	0.4	4.2	4.6	5.1	5.9	6.1



OUTSIDE MIDDLE PHALANGEAL LINKAGE

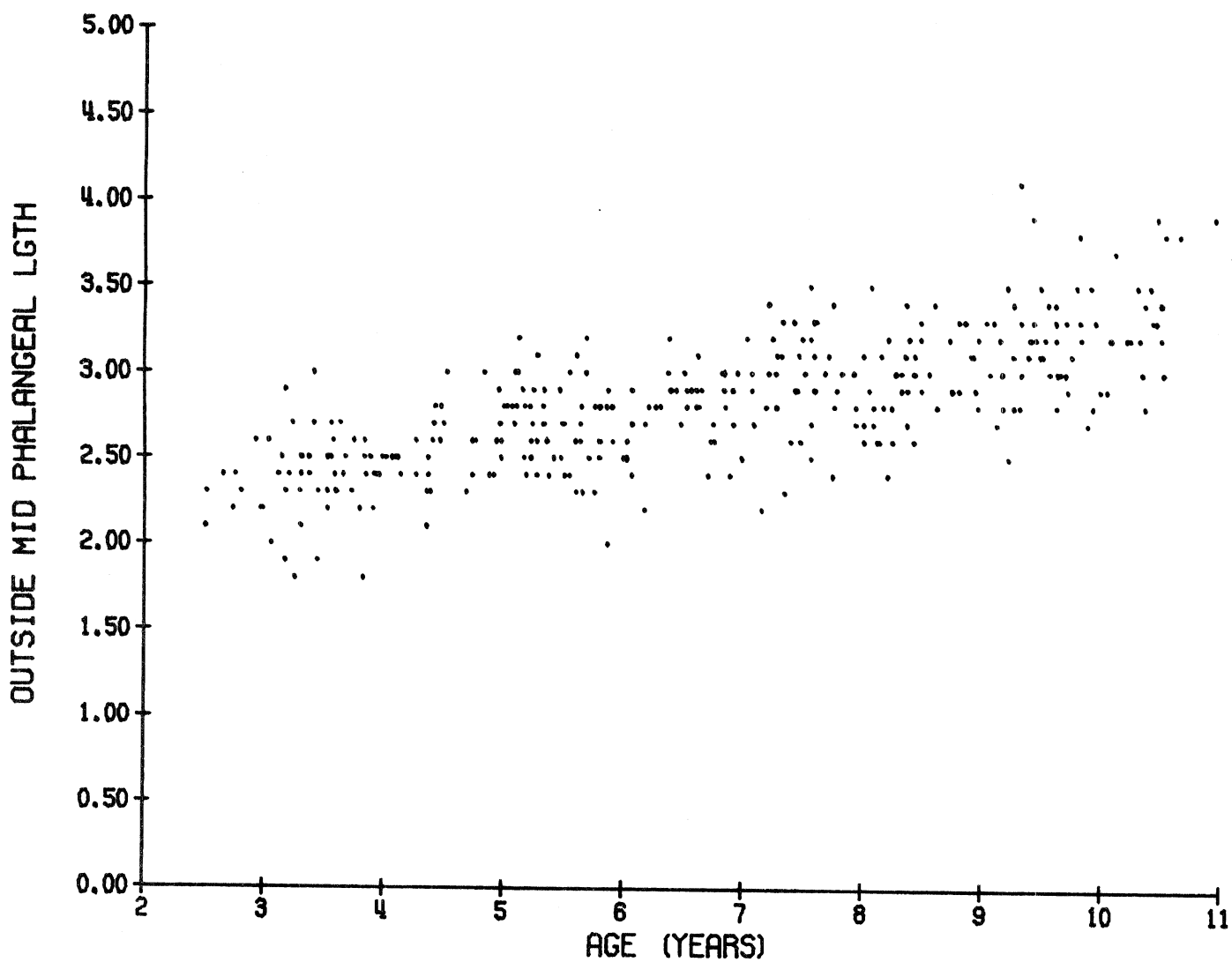
DESCRIPTION: Measure from the outside of the first knuckle of the second finger (distal interphalangeal joint of phalanx III) to the outside of the second knuckle of the second finger (proximal interphalangeal joint of phalanx III) with the hand held in a fist.





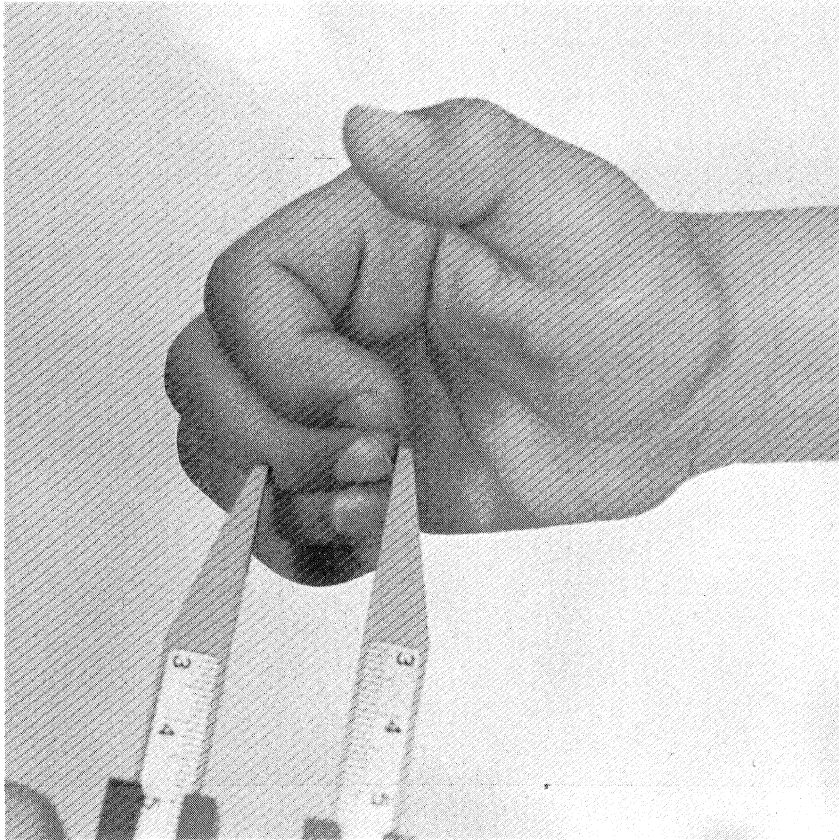
OUTSIDE MIDDLE PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	2.4	0.3	1.8	1.8	2.3	2.8	3.0
3.5-4.5	45	2.4	0.2	1.8	2.1	2.4	2.7	2.8
4.5-5.5	44	2.7	0.2	2.3	2.3	2.6	3.0	3.2
5.5-6.5	49	2.7	0.3	2.0	2.2	2.7	3.1	3.2
6.5-7.5	46	2.9	0.3	2.2	2.3	2.8	3.2	3.4
7.5-8.5	52	2.9	0.3	2.4	2.5	2.9	3.4	3.5
8.5-9.5	42	3.1	0.3	2.5	2.7	3.1	3.5	4.1
9.5-10.5	44	3.3	0.3	2.7	2.7	3.2	3.8	3.9



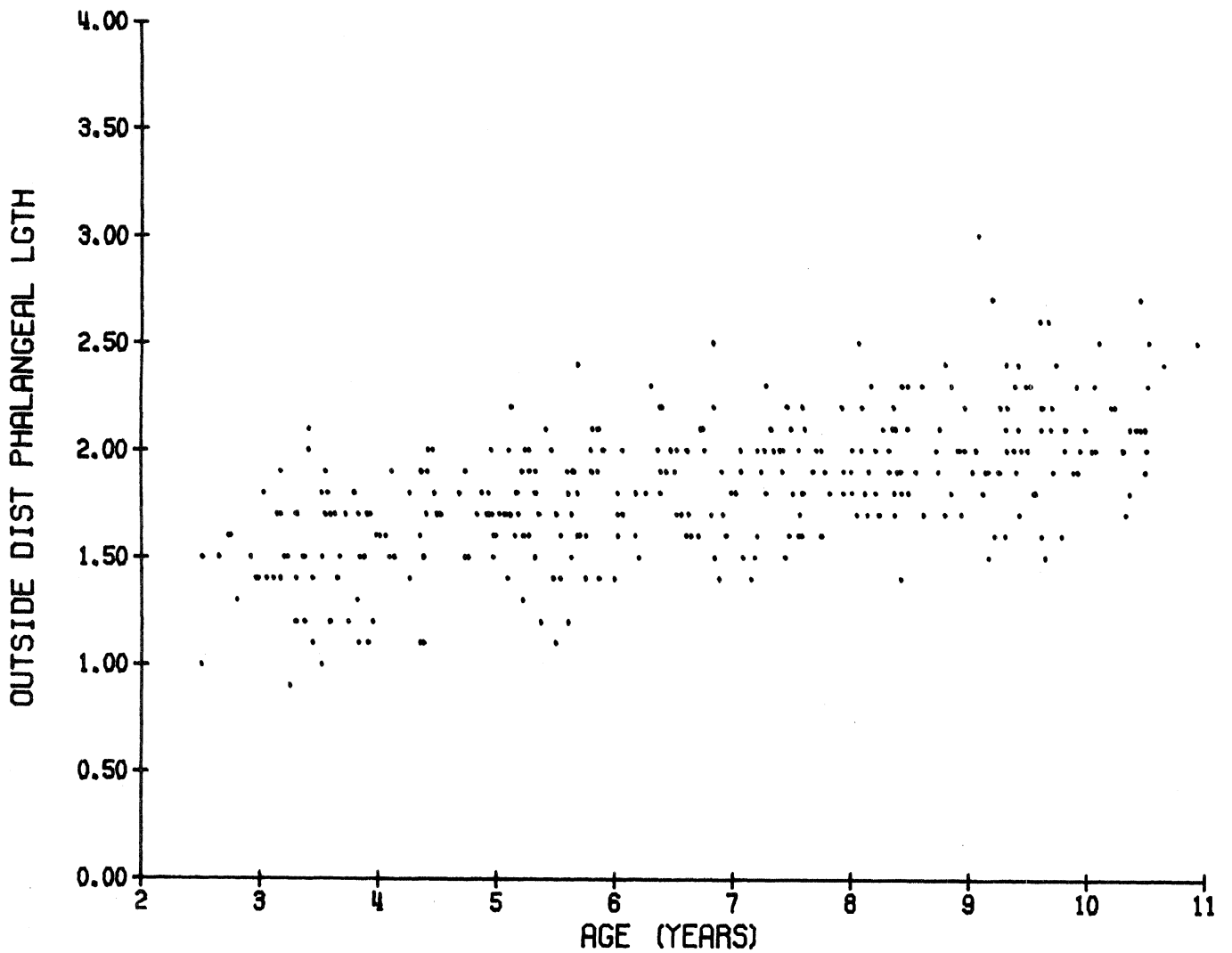
OUTSIDE DISTAL PHALANGEAL LINKAGE

DESCRIPTION: Measure from the tip of the second finger (phalanx III) to the first knuckle of the second finger (distal interphalangeal joint) with the finger fully flexed.



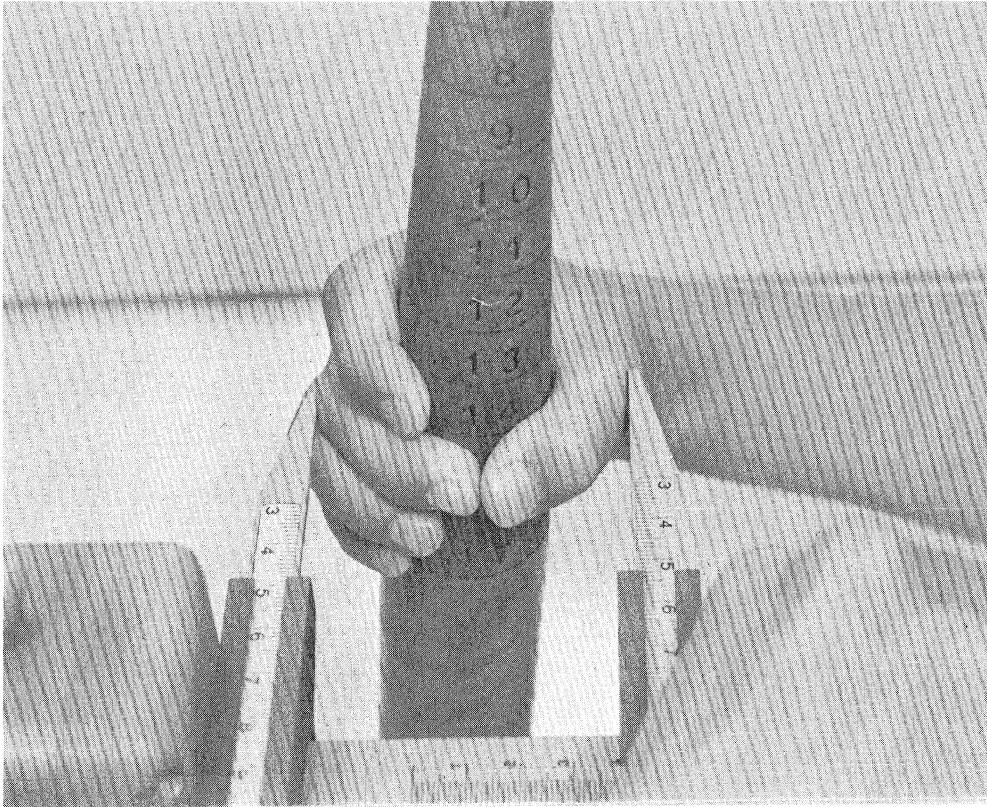
OUTSIDE DISTAL PHALANGEAL LINKAGE (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.5	0.3	0.9	1.0	1.4	1.9	2.1
3.5-4.5	45	1.6	0.3	1.0	1.0	1.6	1.9	2.0
4.5-5.5	44	1.7	0.2	1.2	1.3	1.7	2.0	2.2
5.5-6.5	49	1.8	0.3	1.1	1.2	1.8	2.2	2.4
6.5-7.5	46	1.8	0.3	1.4	1.4	1.8	2.2	2.5
7.5-8.5	52	1.9	0.2	1.4	1.5	1.8	2.3	2.5
8.5-9.5	42	2.0	0.3	1.5	1.6	1.9	2.4	3.0
9.5-10.5	45	2.1	0.3	1.5	1.6	2.0	2.5	2.7



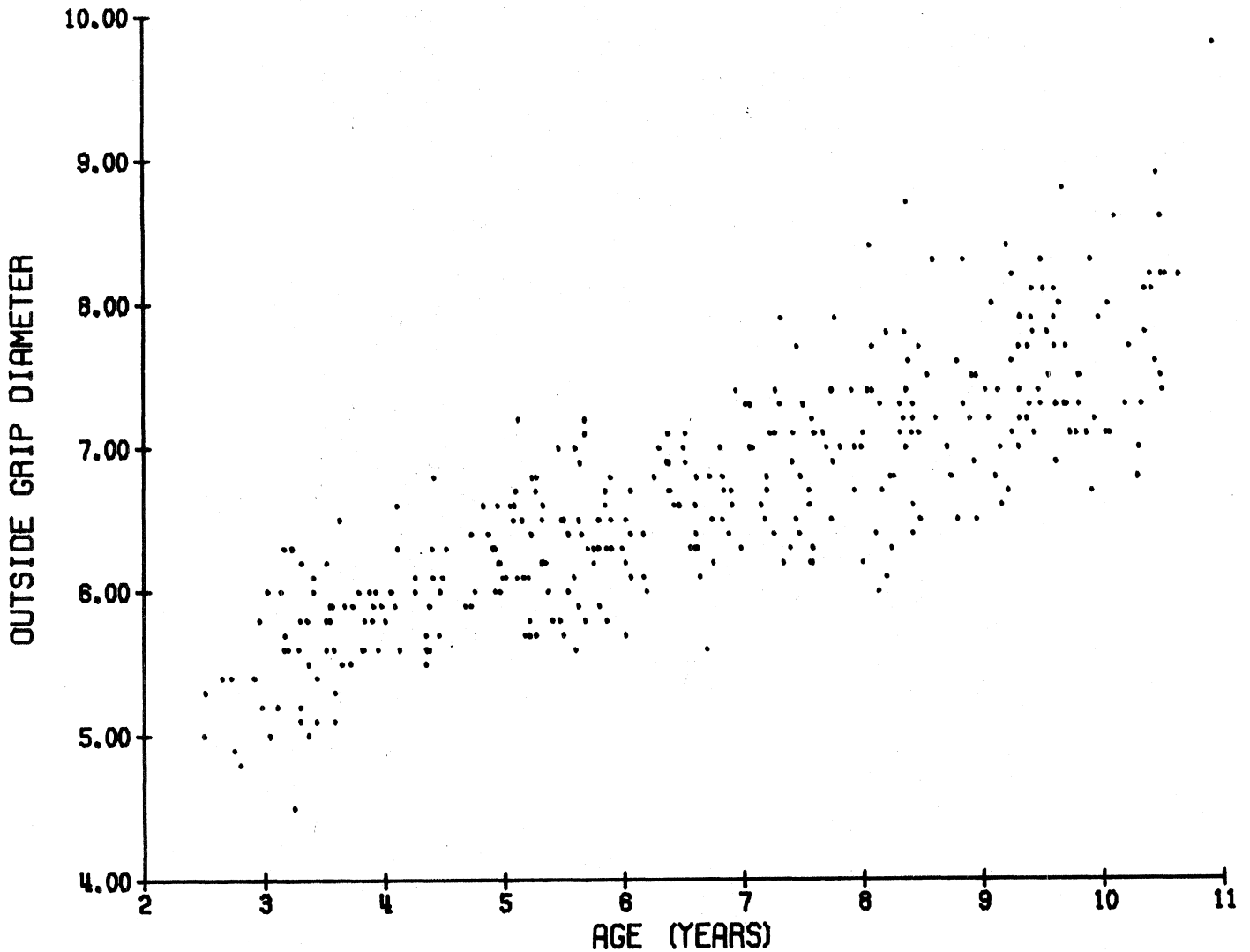
## OUTSIDE GRIP DIAMETER

DESCRIPTION: Measure from the outside of the second knuckle of the second finger (proximal interphalangeal joint of phalanx III) to the outside of the second knuckle of the thumb (metacarpal-phalangeal joint of phalanx I) as the hand encircles a cylindrical object (measuring cone), touching the thumb tip to the second finger tip.



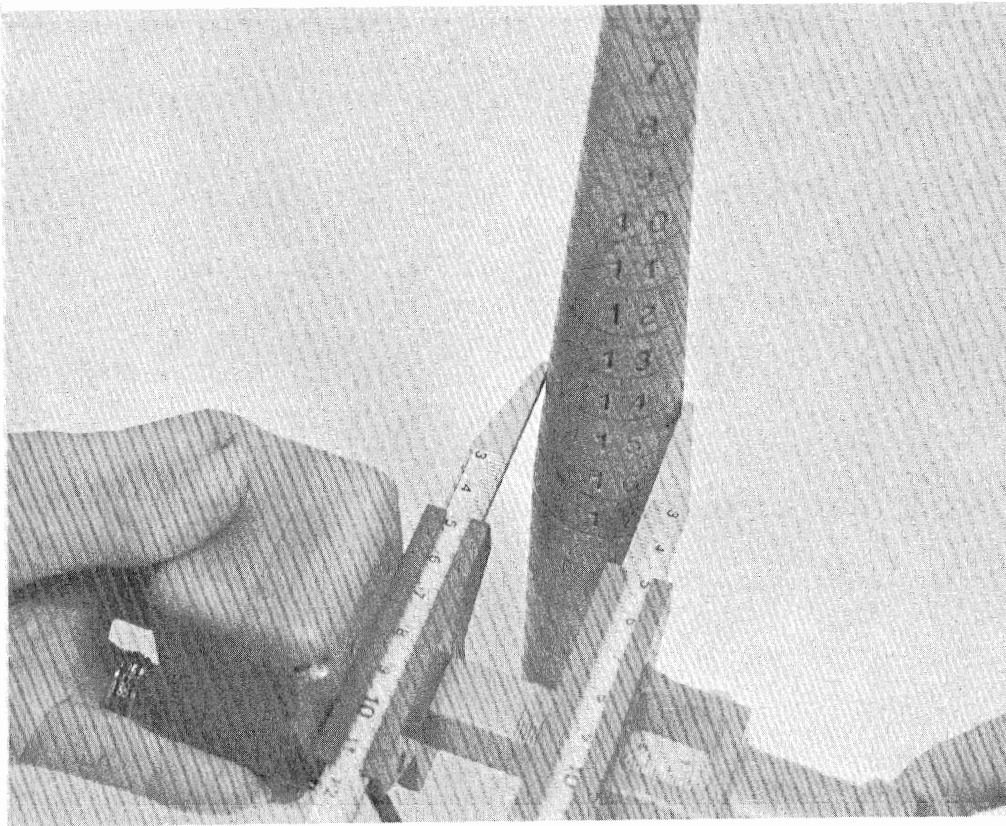
OUTSIDE GRIP DIAMETER (cm)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	5.5	0.5	4.5	4.7	5.4	6.2	6.3
3.5-4.5	45	5.9	0.3	5.1	5.3	5.8	6.4	6.8
4.5-5.5	44	6.3	0.4	5.7	5.7	6.2	6.8	7.2
5.5-6.5	49	6.4	0.4	5.6	5.7	6.4	7.1	7.2
6.5-7.5	46	6.8	0.4	5.6	6.1	6.7	7.4	7.9
7.5-8.5	52	7.0	0.6	6.0	6.1	7.0	7.8	8.7
8.5-9.5	42	7.4	0.5	6.5	6.5	7.3	8.3	8.4
9.5-10.5	45	7.7	0.6	6.7	6.8	7.6	8.7	9.8



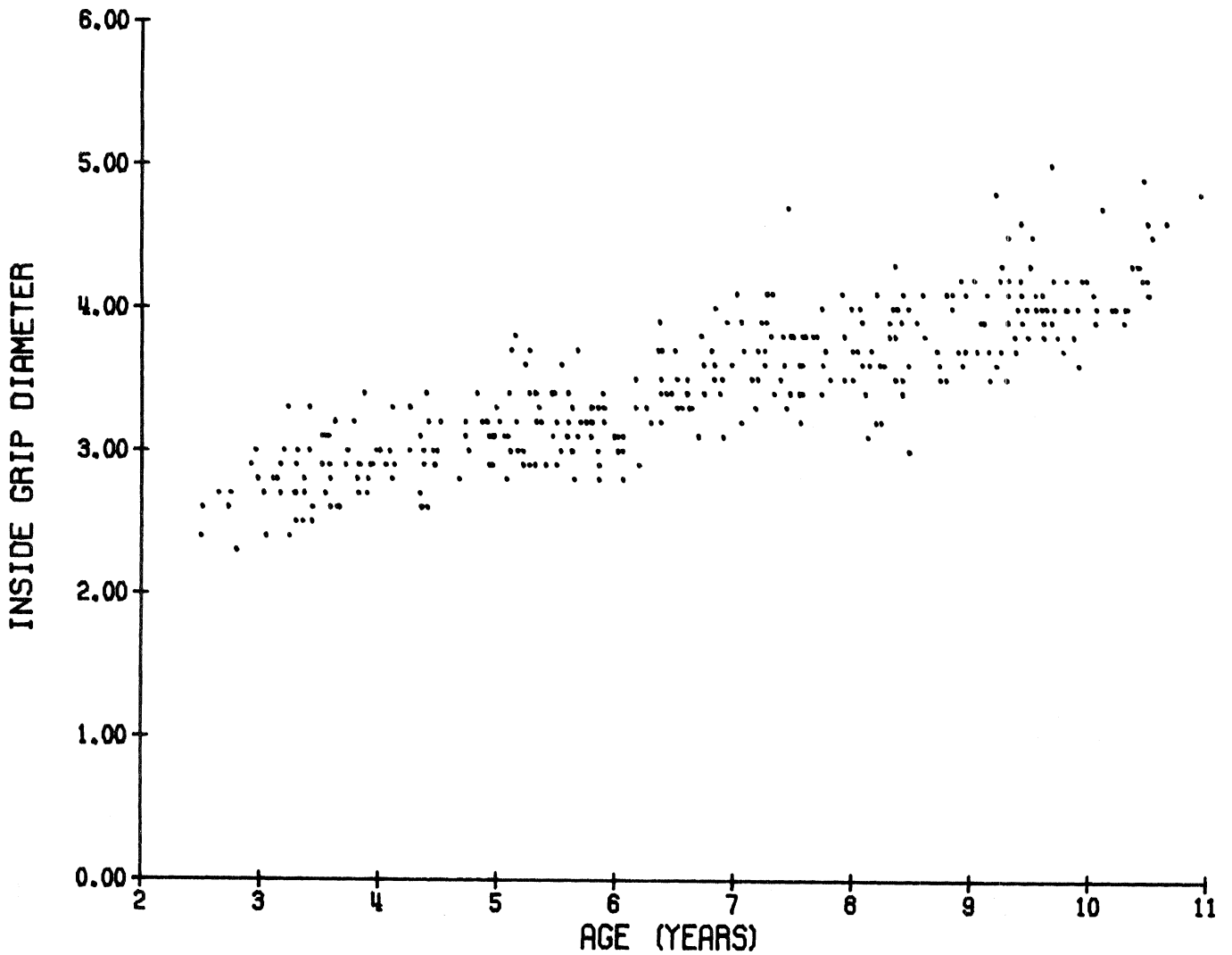
## INSIDE GRIP DIAMETER

DESCRIPTION: Measure the diameter of the cylindrical object (measuring cone) at the point where the hand encircles it touching the thumb tip to the second finger tip.



INSIDE GRIP DIAMETER (cm)  
(Males and Females)

Age (Yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	2.7	0.2	2.3	2.3	2.7	3.1	3.3
3.5-4.5	45	2.9	0.2	2.6	2.6	2.9	3.3	3.4
4.5-5.5	43	3.2	0.2	2.8	2.8	3.1	3.6	3.8
5.5-6.5	49	3.2	0.3	2.8	2.8	3.2	3.7	3.9
6.5-7.5	46	3.6	0.3	3.1	3.1	3.5	4.1	4.7
7.5-8.5	52	3.7	0.3	3.0	3.1	3.6	4.0	4.3
8.5-9.5	42	3.9	0.3	3.5	3.5	3.9	4.5	4.8
9.5-10.5	45	4.2	0.3	3.6	3.7	4.0	4.8	5.0



Anthropometry Statistics  
(2.5 - 3.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	31	97.3	4.3	88.1	89.3	96.6	104.5	104.9
Weight (kg)	31	15.2	1.9	11.2	11.3	15.3	17.6	18.8
Finger Linkage (cm)	31	5.8	0.5	4.8	4.8	5.7	6.5	7.0
Carpal Linkage (cm)	30	4.1	0.5	3.0	3.0	3.9	4.8	5.0
Radial Linkage (cm)	31	12.5	0.8	10.8	11.0	12.5	13.6	13.9
Humeral Length (cm)	31	14.2	1.6	11.1	11.3	14.1	16.9	19.3
Sacral Linkage (cm)	31	5.2	0.8	4.0	4.0	4.9	6.5	7.6
Lumbar Linkage (cm)	31	18.9	2.0	14.1	14.3	19.4	21.5	22.1
Cervical Linkage (cm)	31	11.4	1.3	9.0	9.1	11.5	13.0	13.6
Femoral Linkage (cm)	31	21.2	1.9	17.7	17.8	21.2	23.9	27.0
Tibial Linkage (cm)	31	20.0	2.1	16.1	16.2	19.9	23.1	23.7
Tarsal Linkage (cm)	31	7.8	0.9	6.1	6.2	7.9	9.2	9.7
Clavical Linkage (cm)	31	14.7	1.3	11.7	12.2	14.3	16.7	17.6
Pelvic Linkage (cm)	31	13.3	1.7	10.0	10.2	13.3	15.8	17.0
Distal Phal Linkage (cm)	31	1.3	0.2	0.9	0.9	1.2	1.5	1.6
Middle Phal Linkage (cm)	31	1.6	0.2	1.2	1.2	1.6	2.0	2.4
Proximal Phal Link (cm)	31	2.5	0.3	2.0	2.1	2.5	2.9	3.1
OD Distal Phal Link (cm)	31	1.5	0.3	0.9	1.0	1.4	1.9	2.1
OD Middle Phal Link (cm)	31	2.4	0.3	1.8	1.8	2.3	2.8	3.0
OD Prox Phal Link (cm)	31	3.7	0.3	2.8	2.9	3.6	4.1	4.4
Od Carpal Phal Link (cm)	31	4.4	0.7	3.0	3.2	4.3	5.6	5.8
Fingerfold Linkage (cm)	31	4.5	0.4	3.8	3.8	4.4	5.1	5.3
Hand Length Link (cm)	31	10.4	0.9	8.1	8.7	10.4	11.6	12.2
DIP Finger Breadth (cm)	31	1.1	0.1	0.8	0.8	1.0	1.3	1.4
PIP Finger Breadth (cm)	31	1.2	0.1	0.9	0.9	1.2	1.3	1.4
Hand Breadth-MP (cm)	31	4.9	0.4	4.2	4.2	4.8	5.4	5.8
Hand Breadth-Thumb (cm)	31	5.5	0.5	3.7	4.4	5.6	6.1	6.4
Wrist Breadth (cm)	31	3.6	0.2	3.1	3.2	3.5	3.9	4.1
DIP Thickness (cm)	31	0.9	0.1	0.8	0.8	0.9	1.1	1.2
PIP Thickness (cm)	31	1.1	0.1	0.8	0.8	1.1	1.3	1.3
MP Thickness (cm)	31	1.7	0.2	1.3	1.3	1.6	2.1	2.3
Wrist Thickness (cm)	30	2.7	0.2	2.3	2.3	2.6	3.1	3.2
Grip OD (cm)	31	5.5	0.5	4.5	4.7	5.4	6.2	6.3
Grip ID (cm)	31	2.7	0.2	2.3	2.3	2.7	3.1	3.3



Anthropometry Statistics  
(3.5 - 4.5 years)

Measurement	N	Descriptive Statistics						
		Mean	S.d.	Min	5th	50th	95th	Max
Height (cm)	45	102.1	4.1	93.6	94.2	101.7	108.8	110.4
Weight (kg)	45	16.8	1.9	13.4	14.0	16.5	20.0	20.7
Finger Linkage (cm)	45	6.1	0.4	5.4	5.5	6.1	6.8	7.1
Carpal Linkage (cm)	45	4.3	0.5	2.8	3.5	4.2	5.1	5.2
Radial Linkage (cm)	45	13.3	0.9	11.5	11.6	13.2	14.9	15.6
Humeral Length (cm)	45	15.2	1.5	11.3	12.3	15.1	17.4	18.1
Sacral Linkage (cm)	44	5.7	1.1	3.6	3.8	5.6	7.3	8.3
Lumbar Linkage (cm)	45	20.8	2.1	14.9	16.3	20.7	24.4	25.3
Cervical Linkage (cm)	45	12.9	1.4	9.0	9.3	13.1	14.6	15.1
Femoral Linkage (cm)	45	22.5	1.9	19.0	19.3	22.3	25.7	26.4
Tibial Linkage (cm)	45	21.4	1.6	18.2	18.8	21.3	23.9	24.5
Tarsal Linkage (cm)	45	8.6	1.0	6.8	6.8	8.5	10.0	10.9
Clavical Linkage (cm)	45	15.8	1.6	11.9	12.5	15.8	17.8	19.2
Pelvic Linkage (cm)	45	14.0	1.8	10.0	10.9	13.4	17.2	18.3
Distal Phal Linkage (cm)	44	1.4	0.2	1.0	1.0	1.3	1.6	1.8
Middle Phal Linkage (cm)	45	1.7	0.2	1.3	1.3	1.6	2.0	2.1
Proximal Phal Link (cm)	45	2.7	0.3	1.8	2.0	2.7	3.1	3.6
OD Distal Phal Link (cm)	45	1.6	0.3	1.0	1.0	1.6	1.9	2.0
OD Middle Phal Link (cm)	45	2.4	0.2	1.8	2.1	2.4	2.7	2.8
OD Prox Phal Link (cm)	45	3.9	0.3	3.0	3.5	3.9	4.3	4.6
Od Carpal Phal Link (cm)	45	4.6	0.5	3.6	3.7	4.5	5.5	5.7
Fingerfold Linkage (cm)	45	4.7	0.3	4.1	4.1	4.7	5.1	5.4
Hand Length Link (cm)	45	11.1	0.6	9.9	9.9	11.0	12.0	12.2
DIP Finger Breadth (cm)	45	1.1	0.1	0.8	0.9	1.0	1.2	1.3
PIP Finger Breadth (cm)	45	1.2	0.1	1.0	1.0	1.2	1.4	1.5
Hand Breadth-MP (cm)	45	5.1	0.3	4.3	4.5	5.0	5.5	6.0
Hand Breadth-Thumb (cm)	45	5.9	0.5	4.9	5.1	5.8	6.8	7.1
Wrist Breadth (cm)	45	3.7	0.2	3.3	3.3	3.7	4.1	4.2
DIP Thickness (cm)	45	1.0	0.1	0.8	0.8	0.9	1.1	1.2
PIP Thickness (cm)	45	1.1	0.1	0.9	0.9	1.1	1.3	1.4
MP Thickness (cm)	45	1.8	0.2	1.4	1.4	1.7	2.2	2.5
Wrist Thickness (cm)	45	2.8	0.2	2.4	2.4	2.7	3.2	3.3
Grip OD (cm)	45	5.9	0.3	5.1	5.3	5.8	6.4	6.8
Grip ID (cm)	45	2.9	0.2	2.6	2.6	2.9	3.3	3.4

Anthropometry Statistics  
(4.5 - 5.5 years)

Measurement	Descriptive Statistics							
	N	Mean	S.d.	Min	5th	50th	95th	Max
Height (cm)	44	111.4	5.5	102.3	102.7	111.0	122.3	125.0
Weight (kg)	44	19.6	2.7	15.2	15.4	19.2	24.7	26.4
Finger Linkage (cm)	44	6.7	0.5	5.5	5.7	6.5	7.6	7.9
Carpal Linkage (cm)	44	4.9	0.6	3.7	3.7	4.6	5.7	5.8
Radial Linkage (cm)	44	14.6	1.2	12.0	12.2	14.4	16.7	17.1
Humeral Length (cm)	44	17.0	1.8	13.9	14.1	17.0	19.6	22.3
Sacral Linkage (cm)	44	6.5	1.3	4.0	4.3	6.3	8.8	9.9
Lumbar Linkage (cm)	44	22.3	2.6	16.4	16.7	21.9	26.2	27.8
Cervical Linkage (cm)	44	13.4	1.9	9.9	10.2	13.3	16.3	18.2
Femoral Linkage (cm)	44	25.4	1.8	21.5	22.5	25.1	28.5	30.3
Tibial Linkage (cm)	44	23.8	1.2	21.0	21.7	23.5	25.9	26.6
Tarsal Linkage (cm)	44	9.4	0.9	7.6	7.8	9.4	10.8	11.7
Clavical Linkage (cm)	44	17.3	1.6	12.9	14.9	17.5	20.2	21.5
Pelvic Linkage (cm)	44	15.4	1.8	11.3	11.7	15.6	17.9	18.6
Distal phal Linkage (cm)	44	1.4	0.2	1.1	1.1	1.4	1.8	1.9
Middle phal Linkage (cm)	43	1.8	0.2	1.3	1.3	1.7	2.1	2.2
Proximal phal Link (cm)	43	2.9	0.3	2.3	2.4	2.9	3.3	3.7
OD Distal Phal Link (cm)	44	1.7	0.2	1.2	1.3	1.7	2.0	2.2
OD Middle Phal Link (cm)	44	2.7	0.2	2.3	2.3	2.6	3.0	3.2
OD Prox Phal Link (cm)	44	4.2	0.3	3.5	3.7	4.2	4.6	4.9
Od Carpal Phal Link (cm)	43	5.3	0.7	4.1	4.2	5.2	6.3	7.2
Fingerfold Linkage (cm)	43	5.2	0.4	4.3	4.4	5.1	5.9	6.1
Hand Length Link (cm)	44	12.0	0.8	10.4	10.9	11.8	13.4	13.9
DIP Finger Breadth (cm)	44	1.1	0.1	0.9	0.9	1.1	1.3	1.4
PIP Finger Breadth (cm)	44	1.3	0.1	1.0	1.0	1.2	1.4	1.5
Hand Breadth-MP (cm)	44	5.4	0.3	4.9	4.9	5.2	6.0	6.5
Hand Breadth-Thumb (cm)	44	6.1	0.4	5.4	5.5	6.1	6.7	7.2
Wrist Breadth (cm)	44	3.9	0.2	3.5	3.5	3.8	4.3	4.4
DIP Thickness (cm)	44	1.0	0.1	0.8	0.8	0.9	1.1	1.2
PIP Thickness (cm)	44	1.2	0.1	0.9	0.9	1.1	1.3	1.5
MP Thickness (cm)	42	1.8	0.2	1.5	1.5	1.7	2.0	2.4
Wrist Thickness (cm)	44	2.9	0.2	2.3	2.4	2.8	3.2	3.4
Grip OD (cm)	44	6.3	0.4	5.7	5.7	6.2	6.8	7.2
Grip ID (cm)	43	3.2	0.2	2.8	2.8	3.1	3.6	3.8

Anthropometry Statistics  
(5.5 - 6.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	49	114.5	4.8	99.6	104.9	113.8	121.2	124.2
Weight (kg)	49	21.0	2.8	16.2	16.5	20.7	25.5	29.3
Finger Linkage (cm)	49	6.7	0.5	5.5	5.7	6.6	7.6	7.8
Carpal Linkage (cm)	49	5.2	0.5	3.8	4.1	5.1	6.0	6.3
Radial Linkage (cm)	49	15.2	1.0	13.1	13.2	15.2	16.6	17.0
Humeral Length (cm)	49	17.3	1.6	13.2	14.2	17.2	20.1	21.4
Sacral Linkage (cm)	49	6.9	1.5	4.4	4.5	6.5	9.2	10.4
Lumbar Linkage (cm)	49	22.2	2.3	16.6	18.4	22.0	26.4	27.4
Cervical Linkage (cm)	49	13.7	1.9	9.7	10.6	13.9	16.5	19.3
Femoral Linkage (cm)	49	26.7	1.8	22.0	23.5	26.7	29.1	30.6
Tibial Linkage (cm)	49	24.7	1.9	20.5	21.1	24.4	27.5	29.0
Tarsal Linkage (cm)	49	9.5	1.0	7.1	7.4	9.5	11.0	11.4
Clavical Linkage (cm)	49	17.8	1.5	14.9	15.3	17.6	20.1	21.7
Pelvic Linkage (cm)	49	15.8	1.7	12.7	13.1	15.5	18.4	19.8
Distal Phal Linkage (cm)	49	1.5	0.2	1.0	1.0	1.4	1.8	2.0
Middle Phal Linkage (cm)	49	1.8	0.3	1.1	1.1	1.7	2.3	2.5
Proximal Phal Link (cm)	49	3.0	0.4	2.4	2.4	2.9	3.5	3.8
OD Distal Phal Link (cm)	49	1.8	0.3	1.1	1.2	1.8	2.2	2.4
OD Middle Phal Link (cm)	49	2.7	0.3	2.0	2.2	2.7	3.1	3.2
OD Prox Phal Link (cm)	49	4.4	0.2	3.8	3.9	4.3	4.7	4.8
Od Carpal Phal Link (cm)	49	5.6	0.7	3.9	4.4	5.5	6.7	8.3
Fingerfold Linkage (cm)	49	5.2	0.4	4.3	4.4	5.1	5.8	6.3
Hand Length Link (cm)	49	12.2	0.7	10.5	10.9	12.1	13.2	13.6
DIP Finger Breadth (cm)	49	1.2	0.1	1.0	1.0	1.1	1.3	1.3
PIP Finger Breadth (cm)	48	1.3	0.1	1.1	1.1	1.2	1.4	1.5
Hand Breadth-MP (cm)	49	5.5	0.3	4.8	4.9	5.5	5.9	6.2
Hand Breadth-Thumb (cm)	49	6.4	0.5	5.5	5.5	6.3	7.1	7.6
Wrist Breadth (cm)	49	4.0	0.2	3.5	3.5	3.9	4.2	4.4
DIP Thickness (cm)	49	1.0	0.1	0.8	0.8	0.9	1.2	1.4
PIP Thickness (cm)	48	1.2	0.1	1.0	1.0	1.2	1.4	1.6
MP Thickness (cm)	49	1.9	0.2	1.4	1.4	1.8	2.1	2.2
Wrist Thickness (cm)	49	2.9	0.2	2.4	2.5	2.9	3.2	3.3
Grip OD (cm)	49	6.4	0.4	5.6	5.7	6.4	7.1	7.2
Grip ID (cm)	49	3.2	0.3	2.8	2.8	3.2	3.7	3.9

Anthropometry Statistics  
(6.5 - 7.5 years)

Measurement	N	Mean	s.d.	Descriptive Statistics					Max
				Min	5th	50th	95th		
Height (cm)	46	121.3	6.5	103.4	112.0	121.0	131.9	132.5	
Weight (kg)	46	23.4	3.2	15.6	18.0	23.3	28.1	30.5	
Finger Linkage (cm)	46	7.2	0.5	6.0	6.2	7.2	7.8	7.9	
Carpal Linkage (cm)	46	5.5	0.5	4.4	4.6	5.4	6.2	6.8	
Radial Linkage (cm)	46	16.0	1.3	13.3	13.5	15.7	18.5	19.0	
Humeral Length (cm)	46	19.2	1.8	14.6	15.3	19.5	21.7	22.3	
Sacral Linkage (cm)	46	7.2	1.1	5.1	5.3	7.0	8.7	9.7	
Lumbar Linkage (cm)	46	24.0	2.1	19.9	20.3	23.5	27.6	29.2	
Cervical Linkage (cm)	46	14.7	1.7	9.7	10.6	14.8	17.0	17.6	
Femoral Linkage (cm)	46	28.3	2.1	24.7	25.2	27.7	31.5	32.3	
Tibial Linkage (cm)	46	26.9	1.9	23.0	23.4	26.6	30.4	30.5	
Tarsal Linkage (cm)	46	10.3	1.0	8.6	8.9	10.3	12.0	12.6	
Clavical Linkage (cm)	46	18.1	1.7	14.2	15.2	18.1	21.0	21.7	
Pelvic Linkage (cm)	46	16.3	2.2	11.4	12.2	16.0	19.4	22.5	
Distal Phal Linkage (cm)	46	1.6	0.2	1.2	1.2	1.5	1.8	2.0	
Middle Phal Linkage (cm)	46	1.9	0.3	1.2	1.4	1.9	2.3	2.5	
Proximal Phal Link (cm)	46	3.2	0.3	2.6	2.6	3.2	3.7	3.9	
OD Distal Phal Link (cm)	46	1.8	0.3	1.4	1.4	1.8	2.2	2.5	
OD Middle Phal Link (cm)	46	2.9	0.3	2.2	2.3	2.8	3.2	3.4	
OD Prox Phal Link (cm)	46	4.5	0.3	4.0	4.0	4.5	4.9	5.0	
Od Carpal Phal Link (cm)	43	5.8	0.7	4.3	4.5	5.6	7.1	7.7	
Fingerfold Linkage (cm)	46	5.6	0.4	4.8	4.9	5.5	6.3	6.6	
Hand Length Link (cm)	46	12.9	0.8	11.5	11.8	12.9	14.2	15.0	
DIP Finger Breadth (cm)	46	1.2	0.1	0.9	0.9	1.1	1.3	1.5	
PIP Finger Breadth (cm)	46	1.3	0.2	1.0	1.0	1.3	1.6	1.7	
Hand Breadth-MP (cm)	46	5.7	0.4	4.6	4.9	5.7	6.3	6.5	
Hand Breadth-Thumb (cm)	46	6.6	0.5	5.3	5.6	6.5	7.3	8.1	
Wrist Breadth (cm)	45	4.2	0.3	3.6	3.6	4.1	4.5	4.6	
DIP Thickness (cm)	43	1.0	0.1	0.8	0.8	0.9	1.2	1.5	
PIP Thickness (cm)	45	1.3	0.1	1.0	1.0	1.2	1.4	1.7	
MP Thickness (cm)	46	1.9	0.2	1.3	1.4	1.8	2.2	2.6	
Wrist Thickness (cm)	45	3.0	0.3	2.4	2.5	3.0	3.4	3.7	
Grip OD (cm)	46	6.8	0.4	5.6	6.1	6.7	7.4	7.9	
Grip ID (cm)	46	3.6	0.3	3.1	3.1	3.5	4.1	4.7	

Anthropometry Statistics  
(7.5 - 8.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	52	126.8	5.7	114.7	117.0	125.8	136.0	138.4
Weight (kg)	52	26.4	4.7	19.2	19.5	25.2	34.4	39.6
Finger Linkage (cm)	52	7.5	0.6	6.2	6.3	7.5	8.4	8.7
Carpal Linkage (cm)	52	5.8	0.7	4.4	4.6	5.6	7.0	7.4
Radial Linkage (cm)	52	17.0	1.4	13.7	14.6	16.9	19.4	20.2
Humeral Length (cm)	52	19.7	1.6	16.2	16.6	19.5	22.7	24.1
Sacral Linkage (cm)	52	7.5	1.3	5.2	5.4	7.4	9.9	11.0
Lumbar Linkage (cm)	52	24.9	2.2	20.4	20.8	24.8	28.0	31.3
Cervical Linkage (cm)	52	15.8	1.7	12.8	12.9	15.5	18.8	19.5
Femoral Linkage (cm)	52	30.4	2.2	24.8	25.6	30.2	33.8	35.1
Tibial Linkage (cm)	52	28.5	2.2	24.2	24.7	28.2	31.6	32.9
Tarsal Linkage (cm)	52	10.6	1.1	8.9	8.9	10.6	12.1	14.1
Clavical Linkage (cm)	52	19.3	2.0	15.1	16.1	19.3	22.6	24.8
Pelvic Linkage (cm)	52	17.9	2.4	13.9	14.1	17.2	21.9	23.1
Distal Phal Linkage (cm)	52	1.6	0.3	1.0	1.1	1.6	2.0	2.4
Middle Phal Linkage (cm)	52	2.0	0.3	1.6	1.6	2.0	2.3	2.8
Proximal Phal Link (cm)	52	3.4	0.4	2.5	2.6	3.3	3.9	4.3
OD Distal Phal Link (cm)	52	1.9	0.2	1.4	1.5	1.8	2.3	2.5
OD Middle Phal Link (cm)	52	2.9	0.3	2.4	2.5	2.9	3.4	3.5
OD Prox Phal Link (cm)	51	4.7	0.3	4.0	4.1	4.6	5.2	5.3
Od Carpal Phal Link (cm)	50	6.0	0.8	4.2	4.6	5.9	7.2	8.6
Fingerfold Linkage (cm)	52	5.8	0.5	4.7	5.0	5.8	6.4	6.7
Hand Length Link (cm)	52	13.4	0.9	11.4	11.6	13.5	14.5	14.9
DIP Finger Breadth (cm)	51	1.2	0.1	1.0	1.0	1.1	1.4	1.5
PIP Finger Breadth (cm)	52	1.3	0.1	1.1	1.1	1.3	1.5	1.6
Hand Breadth-MP (cm)	52	6.0	0.4	5.2	5.3	5.9	6.6	7.4
Hand Breadth-Thumb (cm)	51	7.0	0.5	5.8	6.0	7.0	7.7	8.3
Wrist Breadth (cm)	52	4.3	0.3	3.6	3.7	4.2	4.8	5.2
DIP Thickness (cm)	52	1.0	0.1	0.8	0.8	1.0	1.2	1.3
PIP Thickness (cm)	51	1.3	0.2	1.0	1.0	1.3	1.6	1.7
MP Thickness (cm)	52	2.0	0.3	1.2	1.4	1.9	2.4	2.9
Wrist Thickness (cm)	52	3.1	0.3	2.5	2.6	3.0	3.4	3.7
Grip OD (cm)	52	7.0	0.6	6.0	6.1	7.0	7.8	8.7
Grip ID (cm)	52	3.7	0.3	3.0	3.1	3.6	4.0	4.3

Anthropometry Statistics  
(8.5 - 9.5 years)

Measurement	N	Mean	s.d.	Descriptive Statistics						Max
				Min	5th	50th	95th			
Height (cm)	42	133.7	5.6	118.3	124.4	133.0	145.2	148.9		
Weight (kg)	42	30.1	5.0	19.7	22.6	30.0	37.1	44.9		
Finger Linkage (cm)	42	7.8	0.5	7.0	7.1	7.7	8.7	9.0		
Carpal Linkage (cm)	42	6.0	0.8	4.8	4.8	6.0	7.4	8.0		
Radial Linkage (cm)	42	17.7	1.2	15.6	15.7	17.7	19.4	20.0		
Humeral Length (cm)	42	21.4	1.7	17.7	18.0	21.2	24.4	25.5		
Sacral Linkage (cm)	42	7.9	1.6	5.3	5.4	7.6	10.6	11.7		
Iumbar Linkage (cm)	42	26.3	2.8	19.8	20.5	25.8	30.0	33.8		
Cervical Linkage (cm)	42	16.4	1.7	13.3	13.4	16.3	19.0	20.1		
Femoral Linkage (cm)	42	31.5	2.4	24.7	25.3	31.9	34.4	35.8		
Tibial Linkage (cm)	42	30.2	2.1	25.9	26.1	30.0	33.8	34.5		
Tarsal Linkage (cm)	42	11.4	1.4	8.8	9.0	11.2	13.4	15.4		
Clavical Linkage (cm)	42	19.4	1.6	16.4	16.5	19.2	22.5	22.9		
Pelvic Linkage (cm)	42	18.2	2.5	14.1	14.2	17.8	22.9	25.1		
Distal Phal Linkage (cm)	42	1.7	0.2	1.1	1.1	1.7	2.0	2.1		
Middle Phal Linkage (cm)	42	2.1	0.3	1.3	1.5	2.1	2.4	3.0		
Proximal Phal Link (cm)	42	3.5	0.3	2.9	2.9	3.5	4.0	4.3		
OD Distal phal Link (cm)	42	2.0	0.3	1.5	1.6	1.9	2.4	3.0		
OD Middle phal Link (cm)	42	3.1	0.3	2.5	2.7	3.1	3.5	4.1		
OD Prox phal Link (cm)	42	5.0	0.3	4.2	4.5	4.9	5.3	5.5		
Od Carpal Phal Link (cm)	40	6.3	0.7	4.7	5.1	6.2	7.2	8.0		
Fingerfold Linkage (cm)	42	6.2	0.4	5.3	5.4	6.1	6.9	7.1		
Hand Length Linkage (cm)	42	14.2	0.8	12.3	12.9	14.1	15.4	15.9		
DIP Finger Breadth (cm)	42	1.2	0.1	1.0	1.0	1.2	1.4	1.5		
PIP Finger Breadth (cm)	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7		
Hand Breadth-MP (cm)	42	6.3	0.4	5.6	5.6	6.3	6.8	7.0		
Hand Breadth-Thumb (cm)	42	7.4	0.6	6.1	6.2	7.4	8.1	8.6		
Wrist Breadth (cm)	42	4.5	0.3	3.8	3.8	4.4	4.9	5.1		
DIP Thickness (cm)	42	1.1	0.1	0.9	0.9	1.0	1.3	1.3		
PIP Thickness (cm)	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7		
MP Thickness (cm)	42	2.1	0.2	1.8	1.8	2.1	2.4	2.6		
Wrist Thickness (cm)	42	3.2	0.2	2.6	2.7	3.1	3.5	3.9		
Grip OD (cm)	42	7.4	0.5	6.5	6.5	7.3	8.3	8.4		
Grip ID (cm)	42	3.9	0.3	3.5	3.5	3.9	4.5	4.8		

Anthropometry Statistics  
(9.5 - 10.5 years)

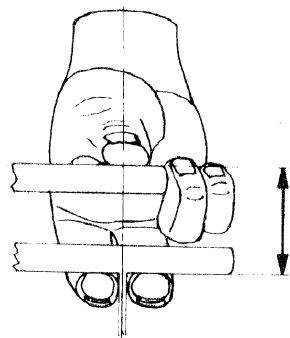
Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	45	140.5	7.2	126.6	127.8	139.2	151.6	158.0
Weight (kg)	45	33.0	4.9	24.3	25.2	31.6	41.6	42.6
Finger Linkage (cm)	45	8.2	0.6	7.1	7.2	8.1	9.3	9.9
Carpal Linkage (cm)	45	6.2	0.9	4.7	4.8	6.0	7.8	8.5
Radial Linkage (cm)	45	18.8	1.5	16.6	16.9	18.4	21.4	23.1
Humeral Length (cm)	45	22.2	1.8	18.5	19.7	21.7	25.4	25.9
Sacral Linkage (cm)	45	8.8	1.6	4.9	6.0	8.7	11.2	13.3
Lumbar Linkage (cm)	45	26.7	2.4	20.5	21.7	26.9	29.9	32.2
Cervical Linkage (cm)	45	17.3	1.5	13.3	14.3	17.4	19.6	20.4
Femoral Linkage (cm)	45	33.6	2.5	27.8	29.5	32.9	37.9	39.4
Tibial Linkage (cm)	45	32.0	2.5	27.8	28.1	31.5	36.6	37.2
Tarsal Linkage (cm)	45	11.6	1.2	8.6	9.2	11.5	13.6	14.2
Clavical Linkage (cm)	45	20.7	2.0	16.2	17.5	20.4	23.8	25.7
Pelvic Linkage (cm)	45	19.1	2.2	14.7	15.1	18.8	23.1	24.7
Distal Phal Linkage (cm)	45	1.9	0.2	1.4	1.4	1.8	2.3	2.4
Middle Phal Linkage (cm)	44	2.2	0.3	1.4	1.5	2.1	2.6	3.0
Proximal Phal Link (cm)	45	3.7	0.4	2.8	2.9	3.7	4.4	4.8
OD Distal phal Link (cm)	45	2.1	0.3	1.5	1.6	2.0	2.5	2.7
OD Middle phal Link (cm)	44	3.3	0.3	2.7	2.7	3.2	3.8	3.9
OD Prox phal Link (cm)	45	5.2	0.4	4.2	4.6	5.1	5.9	6.1
Od Carpal phal Link (cm)	44	6.5	1.1	4.8	4.8	6.2	8.8	9.8
Fingerfold Linkage (cm)	45	6.4	0.6	5.3	5.4	6.2	7.4	8.0
Hand Length Linkage (cm)	45	14.7	1.1	12.9	13.0	14.5	16.7	17.5
DIP Finger Breadth (cm)	45	1.2	0.1	1.0	1.0	1.2	1.4	1.5
PIP Finger Breadth (cm)	45	1.4	0.1	1.2	1.2	1.4	1.6	1.7
Hand Breadth-MP (cm)	45	6.5	0.5	5.5	5.8	6.4	7.2	7.7
Hand Breadth-Thumb (cm)	45	7.5	0.6	6.6	6.6	7.3	8.7	9.4
Wrist Breadth (cm)	45	4.6	0.3	4.1	4.1	4.5	5.1	5.5
DIP Thickness (cm)	45	1.1	0.1	0.9	0.9	1.1	1.3	1.6
PIP Thickness (cm)	44	1.4	0.1	1.2	1.2	1.4	1.6	1.8
MP Thickness (cm)	45	2.2	0.2	1.8	1.8	2.1	2.6	2.7
Wrist Thickness (cm)	45	3.3	0.3	2.8	2.8	3.2	3.7	3.8
Grip OD (cm)	45	7.7	0.6	6.7	6.8	7.6	8.7	9.8
Grip ID (cm)	45	4.2	0.3	3.6	3.7	4.0	4.8	5.0



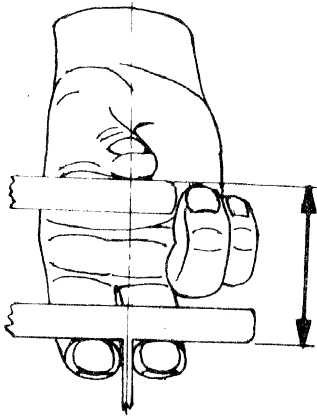




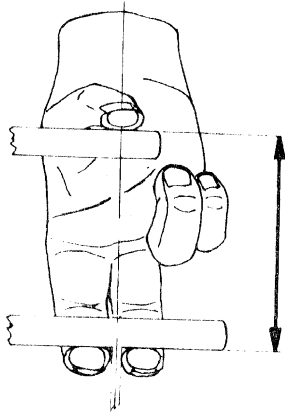
3 Point Pinch



2 - 3 cm

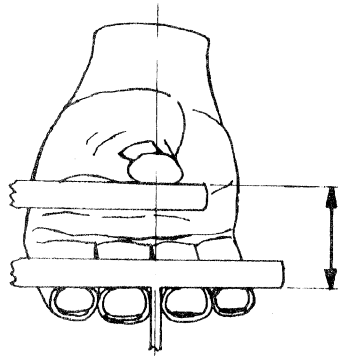


4, 5, 6 cm

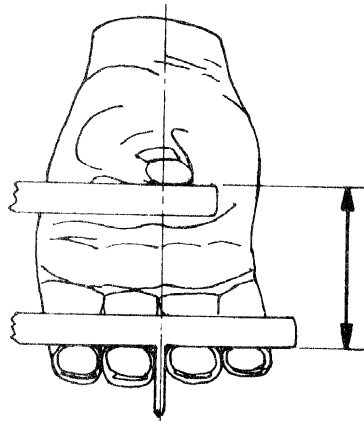


7, 8, 9 cm

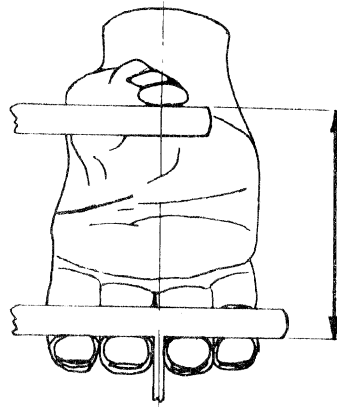
5 Point Pinch



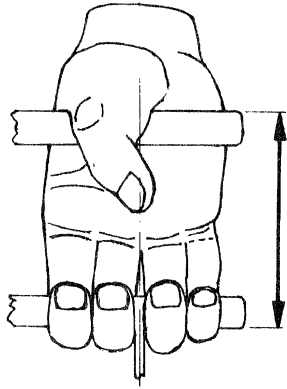
2 - 3 cm



4, 5, 6 cm

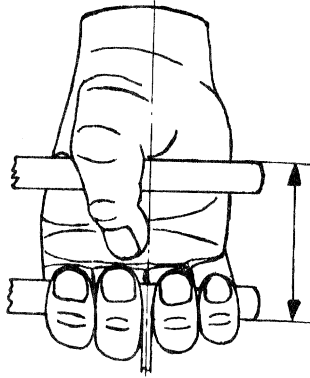


7, 8, 9 cm

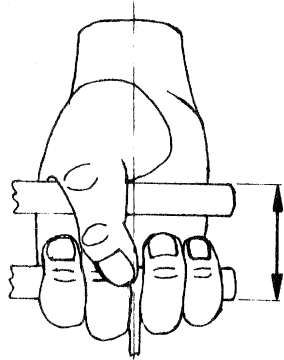


6 - 7 cm

Squeeze



4 - 5 cm



2 - 3 cm

### 3.3.1 Index of Grip Strength Data

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## GRIP: THREE POINT PINCH

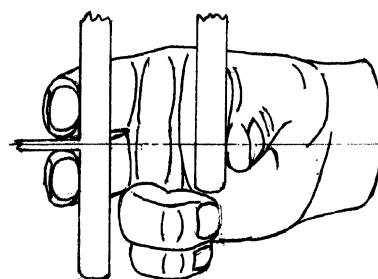
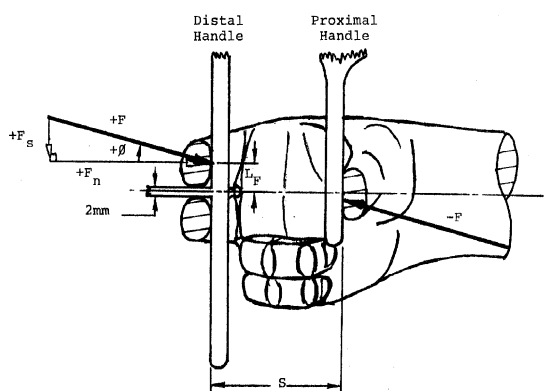
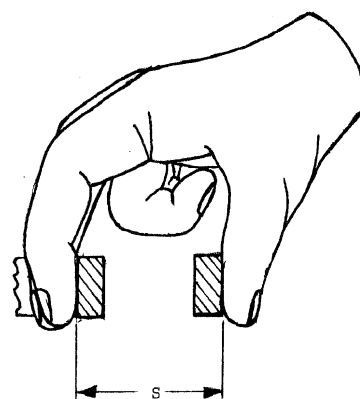
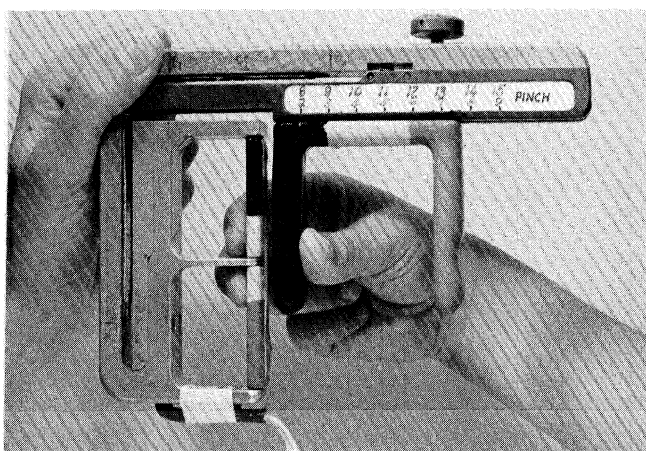
DESCRIPTION OF TEST: The anterior surface of the first two fingers (distal end of phalanges #2 and #3) are pressed in opposition to the anterior surface of the thumb tip (distal end of phalanx #1).

TEST POSITION: The thumb and first two fingers are flexed in the sagittal plane so that the thumb tip is opposite the first and second finger tips and one finger lies on each side of the distal handle brace. The remaining two fingers are flexed in the same plane into a tight fist.

ANTHROPOMETRIC MEASUREMENT: The length of the third phalanx is measured with an anthropometer.

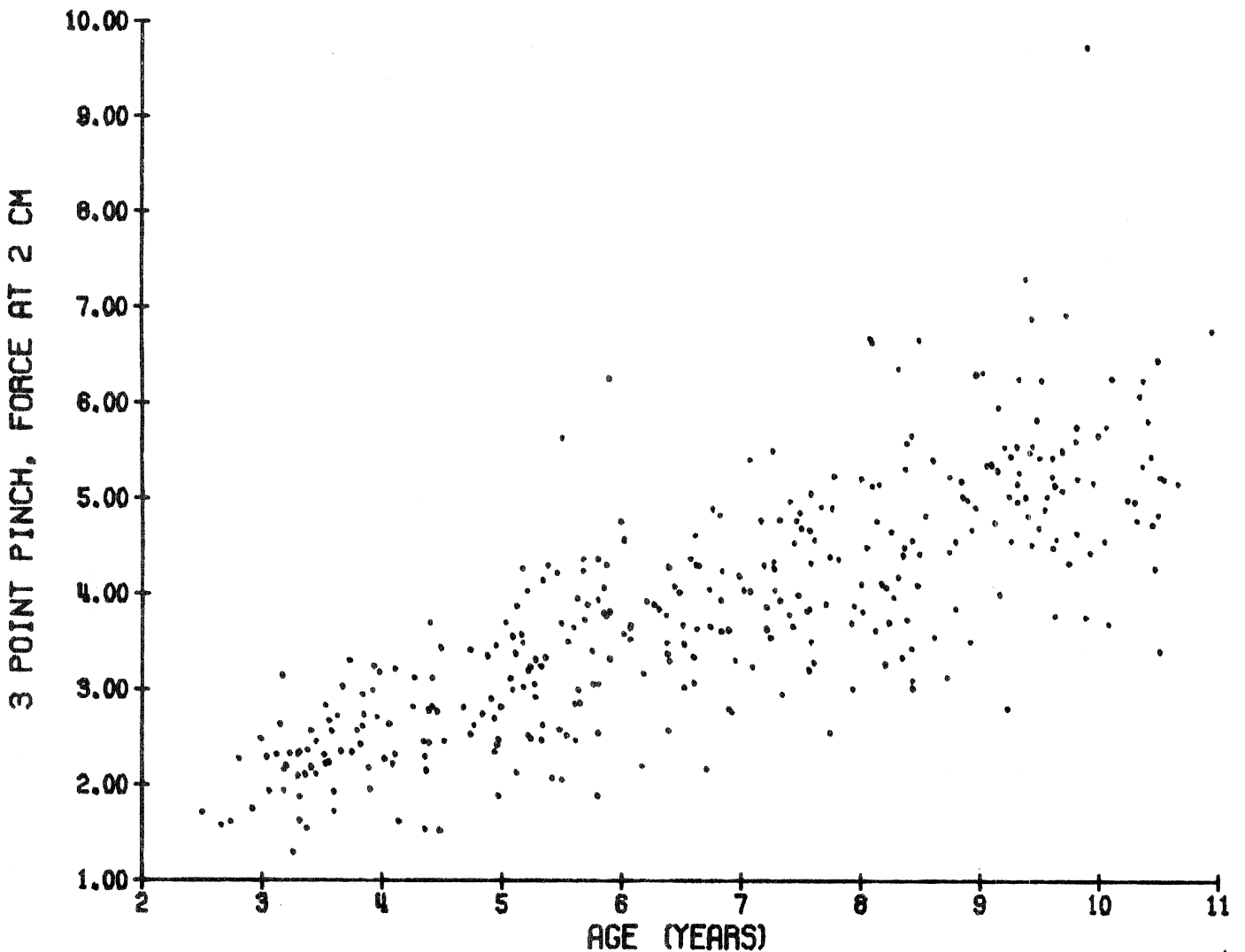
ADJUSTMENT OF EQUIPMENT: The pinch handle set is inserted into the transducer. The handle span (S) is adjusted to the proper test position.

INSTRUCTIONS TO SUBJECT: The child makes a fist and pinches the two plates together using his thumb and first two fingers.



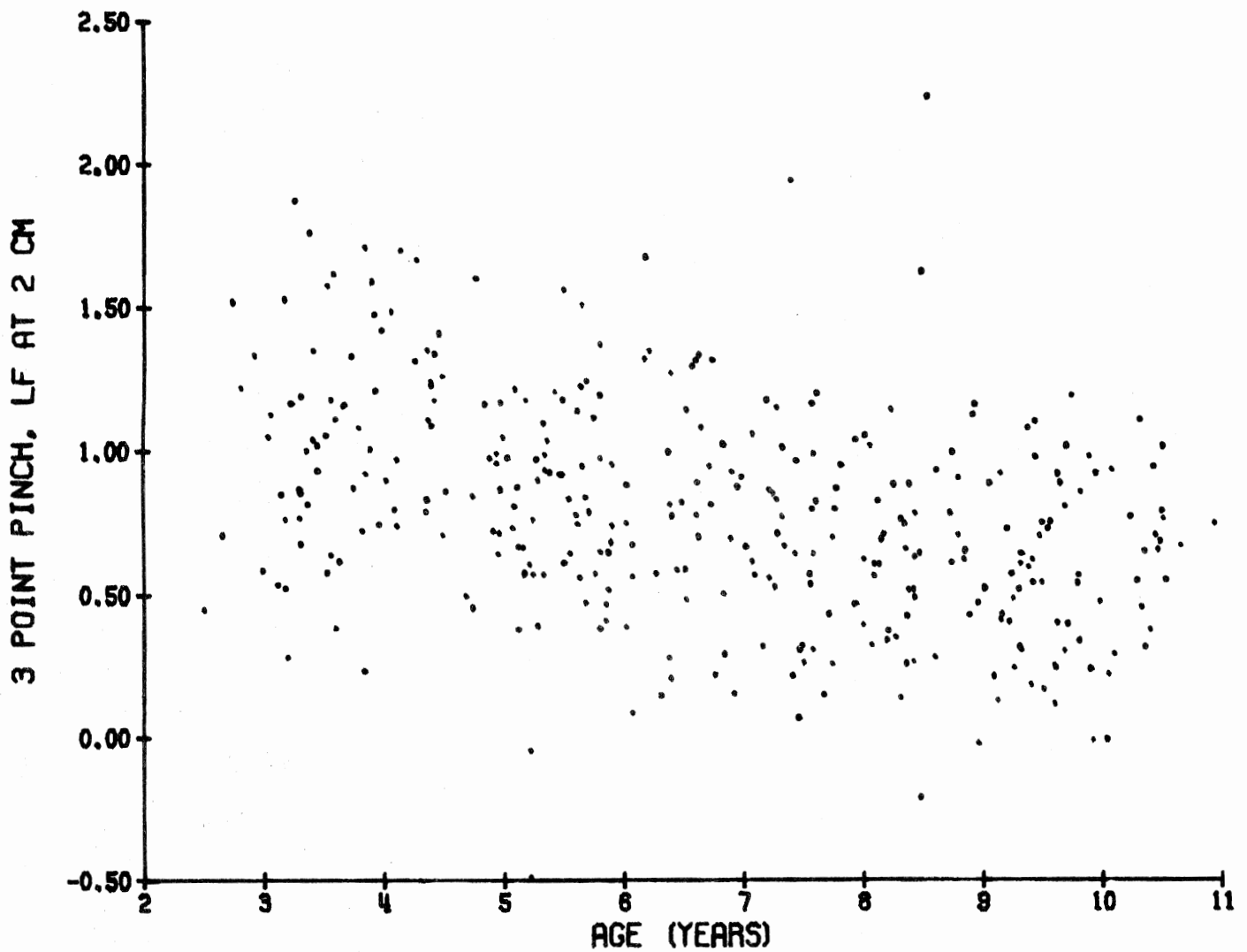
3 POINT PINCH, force at 2 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	2.1	0.4	1.3	1.4	2.2	2.6	3.1
3.5-4.5	44	2.6	0.5	1.5	1.6	2.6	3.3	3.7
4.5-5.5	44	3.1	0.6	1.9	2.1	3.0	4.2	4.3
5.5-6.5	49	3.6	0.8	1.9	2.1	3.7	4.7	6.2
6.5-7.5	46	4.0	0.7	2.2	2.8	4.0	4.9	5.5
7.5-8.5	52	4.4	1.0	2.5	3.0	4.3	6.4	6.7
8.5-9.5	42	5.0	0.9	2.8	3.2	5.0	6.3	7.3
9.5-10.5	44	5.2	1.0	3.4	3.7	5.1	6.7	9.7



3 POINT PINCH, force location at 2 cm  
(Males and Females)

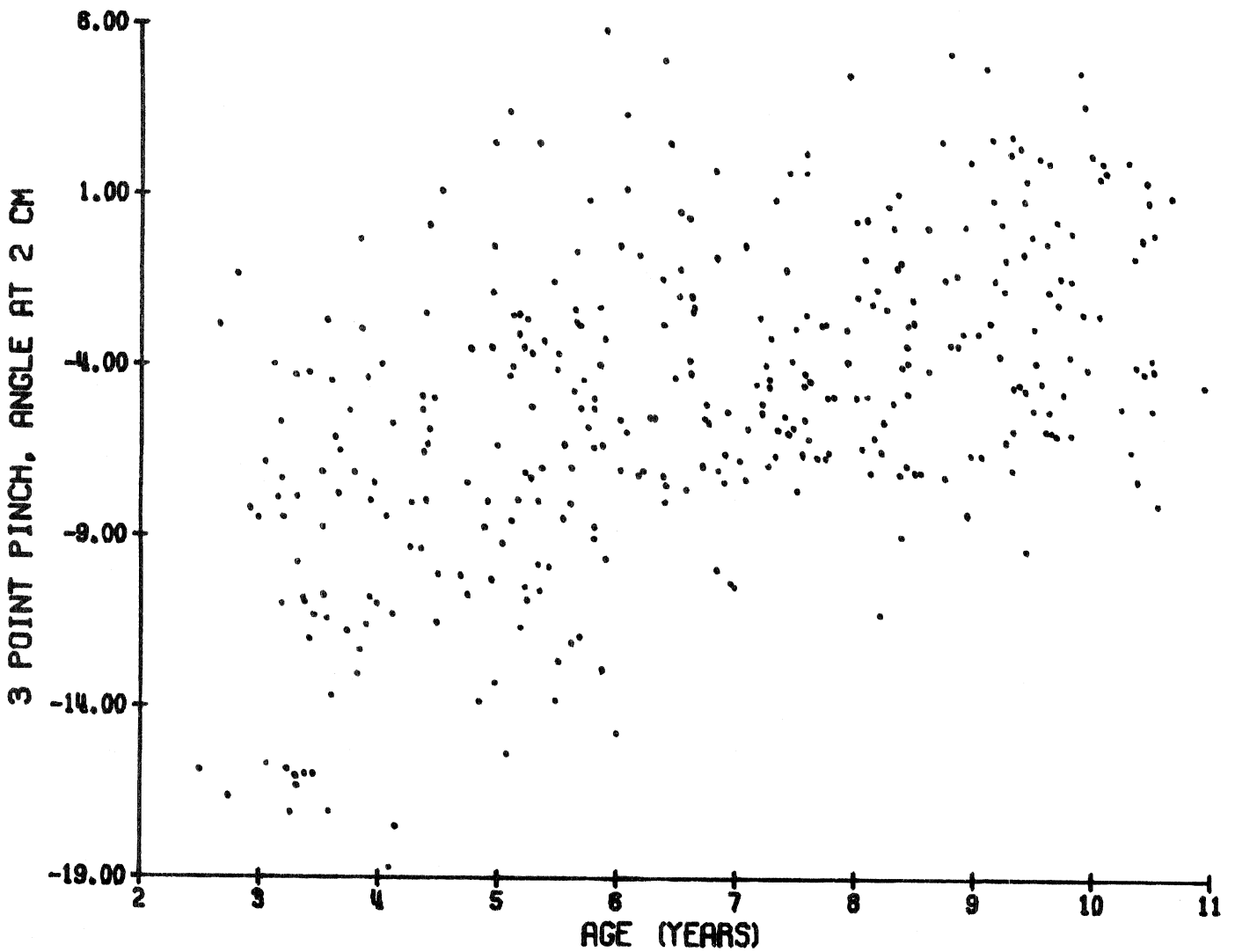
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	1.0	0.4	0.3	0.3	0.9	1.7	1.9
3.5-4.5	44	1.1	0.4	0.2	0.4	1.1	1.7	1.7
4.5-5.5	44	0.8	0.4	-0.5	0.0	0.9	1.2	1.6
5.5-6.5	48	0.8	0.4	0.1	0.2	0.8	1.5	1.7
6.5-7.5	46	0.8	0.4	0.1	0.2	0.8	1.3	1.9
7.5-8.5	52	0.6	0.3	-0.2	0.1	0.6	1.2	1.6
8.5-9.5	42	0.7	0.4	-0.0	0.1	0.6	1.1	2.2
9.5-10.5	44	0.6	0.3	-0.0	0.0	0.7	1.0	1.2





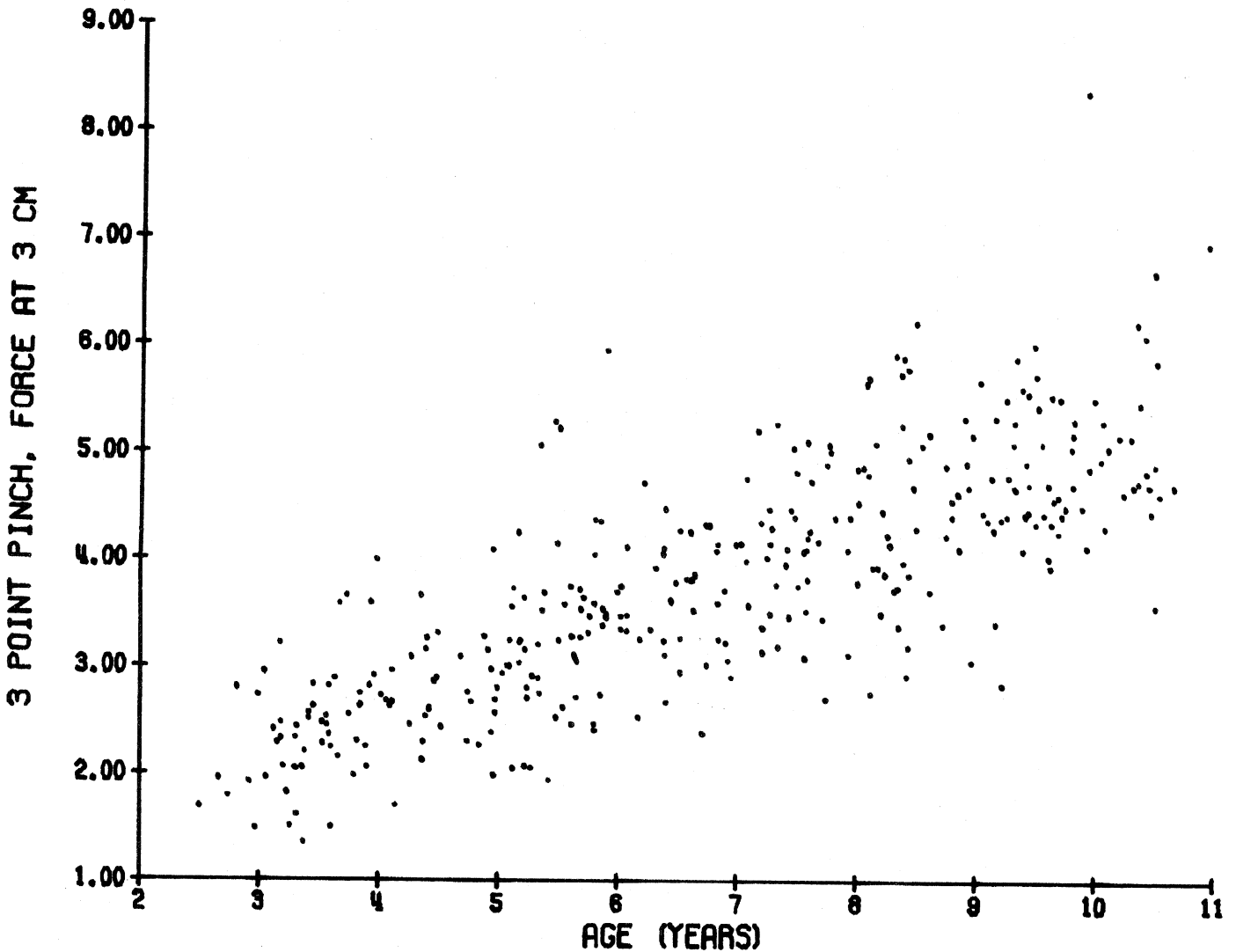
3 POINT PINCH, angle at 2 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	-10.3	4.8	-17.1	-16.9	-10.9	-3.3	-1.4
3.5-4.5	44	-8.2	4.2	-18.7	-17.4	-8.0	-2.6	0.0
4.5-5.5	44	-6.3	4.6	-15.4	-13.9	-7.2	2.2	3.4
5.5-6.5	49	-5.0	4.4	-14.8	-12.8	-5.6	2.9	5.7
6.5-7.5	46	-4.4	3.0	-10.5	-10.3	-5.2	0.7	1.6
7.5-8.5	52	-3.8	3.1	-11.3	-8.3	-4.3	1.2	4.4
8.5-9.5	42	-2.2	3.7	-9.5	-8.3	-2.8	2.6	5.1
9.5-10.5	44	-2.2	3.3	-8.1	-7.2	-2.5	2.1	4.5



3 POINT PINCH, force at 3 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	2.2	0.5	1.4	1.4	2.1	2.9	3.2
3.5-4.5	45	2.7	0.5	1.5	1.8	2.6	3.6	4.0
4.5-5.5	44	3.0	0.7	1.9	2.0	2.9	4.2	5.3
5.5-6.5	49	3.5	0.7	2.4	2.5	3.5	4.6	6.0
6.5-7.5	46	3.9	0.6	2.4	2.9	3.9	5.0	5.3
7.5-8.5	52	4.4	0.9	2.7	2.9	4.2	5.8	6.2
8.5-9.5	42	4.7	0.7	2.9	3.1	4.7	5.7	6.0
9.5-10.5	45	5.0	0.9	3.6	4.0	4.8	6.6	8.4



Anthropometry Statistics  
(5.5 - 6.5 years)

Measurement	N	Mean	s.d.	Descriptive Statistics				
				Min	5th	50th	95th	Max
Height (cm)	49	114.5	4.8	99.6	104.9	113.8	121.2	124.2
Weight (kg)	49	21.0	2.8	16.2	16.5	20.7	25.5	29.3
Finger Linkage (cm)	49	6.7	0.5	5.5	5.7	6.6	7.6	7.8
Carpal Linkage (cm)	49	5.2	0.5	3.8	4.1	5.1	6.0	6.3
Radial Linkage (cm)	49	15.2	1.0	13.1	13.2	15.2	16.6	17.0
Humeral Length (cm)	49	17.3	1.6	13.2	14.2	17.2	20.1	21.4
Sacral Linkage (cm)	49	6.9	1.5	4.4	4.5	6.5	9.2	10.4
Lumbar Linkage (cm)	49	22.2	2.3	16.6	18.4	22.0	26.4	27.4
Cervical Linkage (cm)	49	13.7	1.9	9.7	10.6	13.9	16.5	19.3
Femoral Linkage (cm)	49	26.7	1.8	22.0	23.5	26.7	29.1	30.6
Tibial Linkage (cm)	49	24.7	1.9	20.5	21.1	24.4	27.5	29.0
Tarsal Linkage (cm)	49	9.5	1.0	7.1	7.4	9.5	11.0	11.4
Clavical Linkage (cm)	49	17.8	1.5	14.9	15.3	17.6	20.1	21.7
Pelvic Linkage (cm)	49	15.8	1.7	12.7	13.1	15.5	18.4	19.8
Distal Phal Linkage (cm)	49	1.5	0.2	1.0	1.0	1.4	1.8	2.0
Middle Phal Linkage (cm)	49	1.8	0.3	1.1	1.1	1.7	2.3	2.5
Proximal Phal Link (cm)	49	3.0	0.4	2.4	2.4	2.9	3.5	3.8
OD Distal Phal Link (cm)	49	1.8	0.3	1.1	1.2	1.8	2.2	2.4
OD Middle Phal Link (cm)	49	2.7	0.3	2.0	2.2	2.7	3.1	3.2
OD Prox Phal Link (cm)	49	4.4	0.2	3.8	3.9	4.3	4.7	4.8
Od Carpal Phal Link (cm)	49	5.6	0.7	3.9	4.4	5.5	6.7	8.3
Fingerfold Linkage (cm)	49	5.2	0.4	4.3	4.4	5.1	5.8	6.3
Hand Length Link (cm)	49	12.2	0.7	10.5	10.9	12.1	13.2	13.6
DIP Finger Breadth (cm)	49	1.2	0.1	1.0	1.0	1.1	1.3	1.3
PIP Finger Breadth (cm)	48	1.3	0.1	1.1	1.1	1.2	1.4	1.5
Hand Breadth-MP (cm)	49	5.5	0.3	4.8	4.9	5.5	5.9	6.2
Hand Breadth-Thumb (cm)	49	6.4	0.5	5.5	5.5	6.3	7.1	7.6
Wrist Breadth (cm)	49	4.0	0.2	3.5	3.5	3.9	4.2	4.4
DIP Thickness (cm)	49	1.0	0.1	0.8	0.8	0.9	1.2	1.4
PIP Thickness (cm)	48	1.2	0.1	1.0	1.0	1.2	1.4	1.6
MP Thickness (cm)	49	1.9	0.2	1.4	1.4	1.8	2.1	2.2
Wrist Thickness (cm)	49	2.9	0.2	2.4	2.5	2.9	3.2	3.3
Grip OD (cm)	49	6.4	0.4	5.6	5.7	6.4	7.1	7.2
Grip ID (cm)	49	3.2	0.3	2.8	2.8	3.2	3.7	3.9

Anthropometry Statistics  
(6.5 - 7.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	46	121.3	6.5	103.4	112.0	121.0	131.9	132.5
Weight (kg)	46	23.4	3.2	15.6	18.0	23.3	28.1	30.5
Finger Linkage (cm)	46	7.2	0.5	6.0	6.2	7.2	7.8	7.9
Carpal Linkage (cm)	46	5.5	0.5	4.4	4.6	5.4	6.2	6.8
Radial Linkage (cm)	46	16.0	1.3	13.3	13.5	15.7	18.5	19.0
Humeral Length (cm)	46	19.2	1.8	14.6	15.3	19.5	21.7	22.3
Sacral Linkage (cm)	46	7.2	1.1	5.1	5.3	7.0	8.7	9.7
Lumbar Linkage (cm)	46	24.0	2.1	19.9	20.3	23.5	27.6	29.2
Cervical Linkage (cm)	46	14.7	1.7	9.7	10.6	14.8	17.0	17.6
Femoral Linkage (cm)	46	28.3	2.1	24.7	25.2	27.7	31.5	32.3
Tibial Linkage (cm)	46	26.9	1.9	23.0	23.4	26.6	30.4	30.5
Tarsal Linkage (cm)	46	10.3	1.0	8.6	8.9	10.3	12.0	12.6
Clavical Linkage (cm)	46	18.1	1.7	14.2	15.2	18.1	21.0	21.7
Pelvic Linkage (cm)	46	16.3	2.2	11.4	12.2	16.0	19.4	22.5
Distal Phal Linkage (cm)	46	1.6	0.2	1.2	1.2	1.5	1.8	2.0
Middle Phal Linkage (cm)	46	1.9	0.3	1.2	1.4	1.9	2.3	2.5
Proximal Phal Link (cm)	46	3.2	0.3	2.6	2.6	3.2	3.7	3.9
OD Distal Phal Link (cm)	46	1.8	0.3	1.4	1.4	1.8	2.2	2.5
OD Middle Phal Link (cm)	46	2.9	0.3	2.2	2.3	2.8	3.2	3.4
OD Prox Phal Link (cm)	46	4.5	0.3	4.0	4.0	4.5	4.9	5.0
Od Carpal Phal Link (cm)	43	5.8	0.7	4.3	4.5	5.6	7.1	7.7
Fingerfold Linkage (cm)	46	5.6	0.4	4.8	4.9	5.5	6.3	6.6
Hand Length Link (cm)	46	12.9	0.8	11.5	11.8	12.9	14.2	15.0
DIP Finger Breadth (cm)	46	1.2	0.1	0.9	0.9	1.1	1.3	1.5
PIP Finger Breadth (cm)	46	1.3	0.2	1.0	1.0	1.3	1.6	1.7
Hand Breadth-MP (cm)	46	5.7	0.4	4.6	4.9	5.7	6.3	6.5
Hand Breadth-Thumb (cm)	46	6.6	0.5	5.3	5.6	6.5	7.3	8.1
Wrist Breadth (cm)	45	4.2	0.3	3.6	3.6	4.1	4.5	4.6
DIP Thickness (cm)	43	1.0	0.1	0.8	0.8	0.9	1.2	1.5
PIP Thickness (cm)	45	1.3	0.1	1.0	1.0	1.2	1.4	1.7
MP Thickness (cm)	46	1.9	0.2	1.3	1.4	1.8	2.2	2.6
Wrist Thickness (cm)	45	3.0	0.3	2.4	2.5	3.0	3.4	3.7
Grip OD (cm)	46	6.8	0.4	5.6	6.1	6.7	7.4	7.9
Grip ID (cm)	46	3.6	0.3	3.1	3.1	3.5	4.1	4.7

Anthropometry Statistics  
(7.5 - 8.5 years)

Measurement	Descriptive Statistics							
	N	Mean	S.d.	Min	5th	50th	95th	Max
Height (cm)	52	126.8	5.7	114.7	117.0	125.8	136.0	138.4
Weight (kg)	52	26.4	4.7	19.2	19.5	25.2	34.4	39.6
Finger Linkage (cm)	52	7.5	0.6	6.2	6.3	7.5	8.4	8.7
Carpal Linkage (cm)	52	5.8	0.7	4.4	4.6	5.6	7.0	7.4
Radial Linkage (cm)	52	17.0	1.4	13.7	14.6	16.9	19.4	20.2
Humeral Length (cm)	52	19.7	1.6	16.2	16.6	19.5	22.7	24.1
Sacral Linkage (cm)	52	7.5	1.3	5.2	5.4	7.4	9.9	11.0
Lumbar Linkage (cm)	52	24.9	2.2	20.4	20.8	24.8	28.0	31.3
Cervical Linkage (cm)	52	15.8	1.7	12.8	12.9	15.5	18.8	19.5
Femoral Linkage (cm)	52	30.4	2.2	24.8	25.6	30.2	33.8	35.1
Tibial Linkage (cm)	52	28.5	2.2	24.2	24.7	28.2	31.6	32.9
Tarsal Linkage (cm)	52	10.6	1.1	8.9	8.9	10.6	12.1	14.1
Clavical Linkage (cm)	52	19.3	2.0	15.1	16.1	19.3	22.6	24.8
Pelvic Linkage (cm)	52	17.9	2.4	13.9	14.1	17.2	21.9	23.1
Distal Phal Linkage (cm)	52	1.6	0.3	1.0	1.1	1.6	2.0	2.4
Middle Phal Linkage (cm)	52	2.0	0.3	1.6	1.6	2.0	2.3	2.8
Proximal Phal Link (cm)	52	3.4	0.4	2.5	2.6	3.3	3.9	4.3
OD Distal Phal Link (cm)	52	1.9	0.2	1.4	1.5	1.8	2.3	2.5
OD Middle Phal Link (cm)	52	2.9	0.3	2.4	2.5	2.9	3.4	3.5
OD Prox Phal Link (cm)	51	4.7	0.3	4.0	4.1	4.6	5.2	5.3
Od Carpal Phal Link (cm)	50	6.0	0.8	4.2	4.6	5.9	7.2	8.6
Fingerfold Linkage (cm)	52	5.8	0.5	4.7	5.0	5.8	6.4	6.7
Hand Length Link (cm)	52	13.4	0.9	11.4	11.6	13.5	14.5	14.9
DIP Finger Breadth (cm)	51	1.2	0.1	1.0	1.0	1.1	1.4	1.5
PIP Finger Breadth (cm)	52	1.3	0.1	1.1	1.1	1.3	1.5	1.6
Hand Breadth-MP (cm)	52	6.0	0.4	5.2	5.3	5.9	6.6	7.4
Hand Breadth-Thumb (cm)	51	7.0	0.5	5.8	6.0	7.0	7.7	8.3
Wrist Breadth (cm)	52	4.3	0.3	3.6	3.7	4.2	4.8	5.2
DIP Thickness (cm)	52	1.0	0.1	0.8	0.8	1.0	1.2	1.3
PIP Thickness (cm)	51	1.3	0.2	1.0	1.0	1.3	1.6	1.7
MP Thickness (cm)	52	2.0	0.3	1.2	1.4	1.9	2.4	2.9
Wrist Thickness (cm)	52	3.1	0.3	2.5	2.6	3.0	3.4	3.7
Grip OD (cm)	52	7.0	0.6	6.0	6.1	7.0	7.8	8.7
Grip ID (cm)	52	3.7	0.3	3.0	3.1	3.6	4.0	4.3

Anthropometry Statistics  
(8.5 - 9.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	42	133.7	5.6	118.3	124.4	133.0	145.2	148.9
Weight (kg)	42	30.1	5.0	19.7	22.6	30.0	37.1	44.9
Finger linkage (cm)	42	7.8	0.5	7.0	7.1	7.7	8.7	9.0
Carpal linkage (cm)	42	6.0	0.8	4.8	4.8	6.0	7.4	8.0
Radial linkage (cm)	42	17.7	1.2	15.6	15.7	17.7	19.4	20.0
Humeral Length (cm)	42	21.4	1.7	17.7	18.0	21.2	24.4	25.5
Sacral linkage (cm)	42	7.9	1.6	5.3	5.4	7.6	10.6	11.7
Iumbar linkage (cm)	42	26.3	2.8	19.8	20.5	25.8	30.0	33.8
Cervical linkage (cm)	42	16.4	1.7	13.3	13.4	16.3	19.0	20.1
Femoral linkage (cm)	42	31.5	2.4	24.7	25.3	31.9	34.4	35.8
Tibial linkage (cm)	42	30.2	2.1	25.9	26.1	30.0	33.8	34.5
Tarsal linkage (cm)	42	11.4	1.4	8.8	9.0	11.2	13.4	15.4
Clavical linkage (cm)	42	19.4	1.6	16.4	16.5	19.2	22.5	22.9
pelvic linkage (cm)	42	18.2	2.5	14.1	14.2	17.8	22.9	25.1
Distal Phal Linkage (cm)	42	1.7	0.2	1.1	1.1	1.7	2.0	2.1
Middle Phal Linkage (cm)	42	2.1	0.3	1.3	1.5	2.1	2.4	3.0
Proximal Phal Link (cm)	42	3.5	0.3	2.9	2.9	3.5	4.0	4.3
OD Distal phal Link (cm)	42	2.0	0.3	1.5	1.6	1.9	2.4	3.0
OD Middle Phal Link (cm)	42	3.1	0.3	2.5	2.7	3.1	3.5	4.1
OD Prox Phal Link (cm)	42	5.0	0.3	4.2	4.5	4.9	5.3	5.5
Od Carpal Phal Link (cm)	40	6.3	0.7	4.7	5.1	6.2	7.2	8.0
Fingerfold Linkage (cm)	42	6.2	0.4	5.3	5.4	6.1	6.9	7.1
Hand Length Link (cm)	42	14.2	0.8	12.3	12.9	14.1	15.4	15.9
DIP Finger Breadth (cm)	42	1.2	0.1	1.0	1.0	1.2	1.4	1.5
PIP Finger Breadth (cm)	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7
Hand Breadth-mp (cm)	42	6.3	0.4	5.6	5.6	6.3	6.8	7.0
Hand Breadth-Thumb (cm)	42	7.4	0.6	6.1	6.2	7.4	8.1	8.6
Wrist Breadth (cm)	42	4.5	0.3	3.8	3.8	4.4	4.9	5.1
DIP Thickness (cm)	42	1.1	0.1	0.9	0.9	1.0	1.3	1.3
PIP Thickness (cm)	42	1.4	0.1	1.2	1.2	1.4	1.6	1.7
MP Thickness (cm)	42	2.1	0.2	1.8	1.8	2.1	2.4	2.6
Wrist Thickness (cm)	42	3.2	0.2	2.6	2.7	3.1	3.5	3.9
Grip OD (cm)	42	7.4	0.5	6.5	6.5	7.3	8.3	8.4
Grip ID (cm)	42	3.9	0.3	3.5	3.5	3.9	4.5	4.8

Anthropometry Statistics  
(9.5 - 10.5 years)

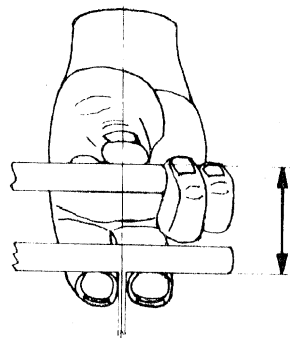
Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	5th	50th	95th	Max
Height (cm)	45	140.5	7.2	126.6	127.8	139.2	151.6	158.0
Weight (kg)	45	33.0	4.9	24.3	25.2	31.6	41.6	42.6
Finger Linkage (cm)	45	8.2	0.6	7.1	7.2	8.1	9.3	9.9
Carpal Linkage (cm)	45	6.2	0.9	4.7	4.8	6.0	7.8	8.5
Radial Linkage (cm)	45	18.8	1.5	16.6	16.9	18.4	21.4	23.1
Humeral Length (cm)	45	22.2	1.8	18.5	19.7	21.7	25.4	25.9
Sacral Linkage (cm)	45	8.8	1.6	4.9	6.0	8.7	11.2	13.3
Lumbar Linkage (cm)	45	26.7	2.4	20.5	21.7	26.9	29.9	32.2
Cervical Linkage (cm)	45	17.3	1.5	13.3	14.3	17.4	19.6	20.4
Femoral Linkage (cm)	45	33.6	2.5	27.8	29.5	32.9	37.9	39.4
Tibial Linkage (cm)	45	32.0	2.5	27.8	28.1	31.5	36.6	37.2
Tarsal Linkage (cm)	45	11.6	1.2	8.6	9.2	11.5	13.6	14.2
Clavical Linkage (cm)	45	20.7	2.0	16.2	17.5	20.4	23.8	25.7
Pelvic Linkage (cm)	45	19.1	2.2	14.7	15.1	18.8	23.1	24.7
Distal Phal Linkage (cm)	45	1.9	0.2	1.4	1.4	1.8	2.3	2.4
Middle Phal Linkage (cm)	44	2.2	0.3	1.4	1.5	2.1	2.6	3.0
Proximal Phal Link (cm)	45	3.7	0.4	2.8	2.9	3.7	4.4	4.8
OD Distal phal Link (cm)	45	2.1	0.3	1.5	1.6	2.0	2.5	2.7
OD Middle phal Link (cm)	44	3.3	0.3	2.7	2.7	3.2	3.8	3.9
OD Prox phal Link (cm)	45	5.2	0.4	4.2	4.6	5.1	5.9	6.1
Od Carpal phal Link (cm)	44	6.5	1.1	4.8	4.8	6.2	8.8	9.8
Fingerfold Linkage (cm)	45	6.4	0.6	5.3	5.4	6.2	7.4	8.0
Hand Length Link (cm)	45	14.7	1.1	12.9	13.0	14.5	16.7	17.5
DIP Finger Breadth (cm)	45	1.2	0.1	1.0	1.0	1.2	1.4	1.5
PIP Finger Breadth (cm)	45	1.4	0.1	1.2	1.2	1.4	1.6	1.7
Hand Breadth-MP (cm)	45	6.5	0.5	5.5	5.8	6.4	7.2	7.7
Hand Breadth-Thumb (cm)	45	7.5	0.6	6.6	6.6	7.3	8.7	9.4
Wrist Breadth (cm)	45	4.6	0.3	4.1	4.1	4.5	5.1	5.5
DIP Thickness (cm)	45	1.1	0.1	0.9	0.9	1.1	1.3	1.6
PIP Thickness (cm)	44	1.4	0.1	1.2	1.2	1.4	1.6	1.8
MP Thickness (cm)	45	2.2	0.2	1.8	1.8	2.1	2.6	2.7
Wrist Thickness (cm)	45	3.3	0.3	2.8	2.8	3.2	3.7	3.8
Grip OD (cm)	45	7.7	0.6	6.7	6.8	7.6	8.7	9.8
Grip ID (cm)	45	4.2	0.3	3.6	3.7	4.0	4.8	5.0



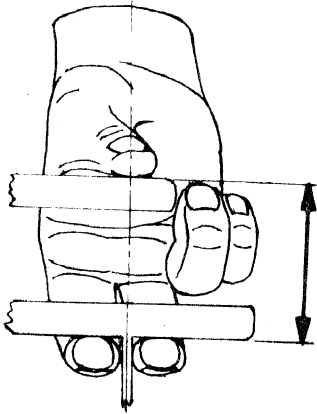




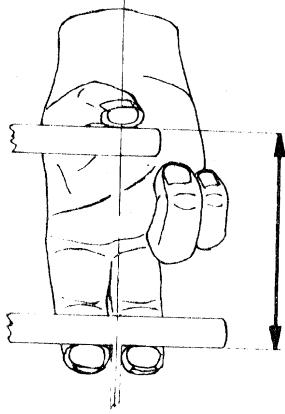
3 Point Pinch



2 - 3 cm

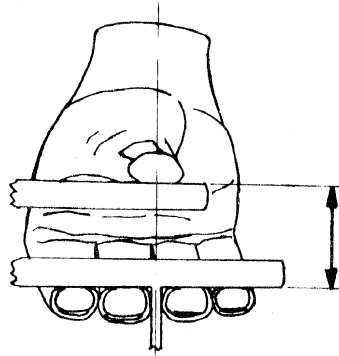


4, 5, 6 cm

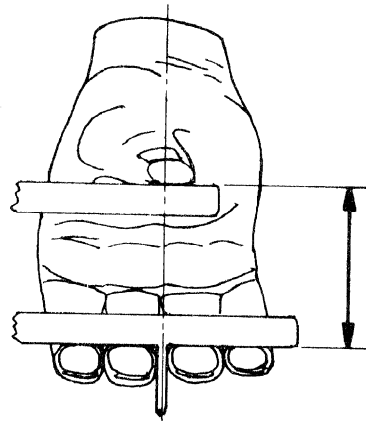


7, 8, 9 cm

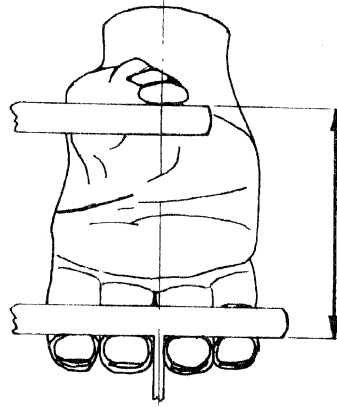
5 Point Pinch



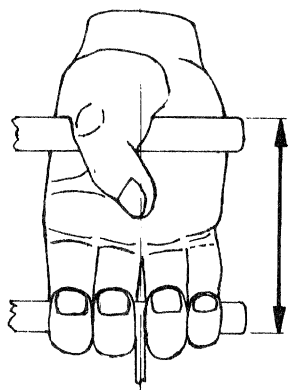
2 - 3 cm



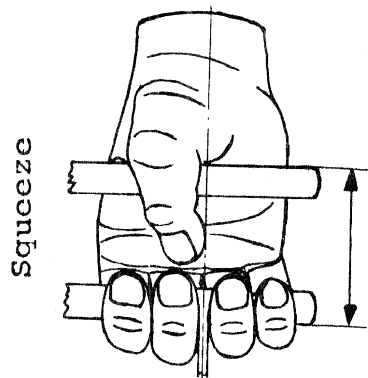
4, 5, 6 cm



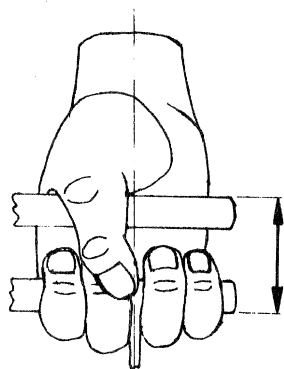
7, 8, 9 cm



6 - 7 cm



4 - 5 cm



2 - 3 cm

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## GRIP: THREE POINT PINCH

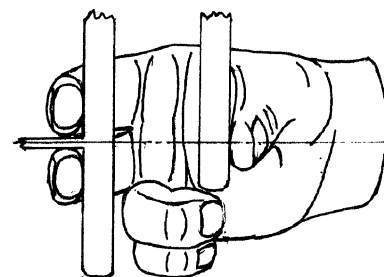
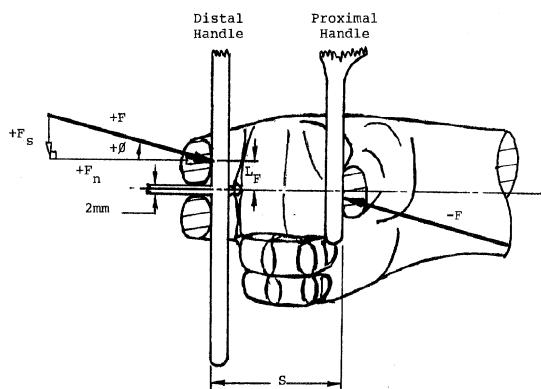
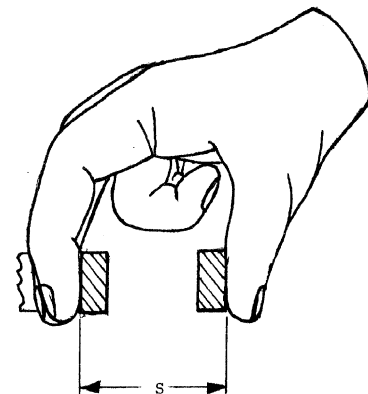
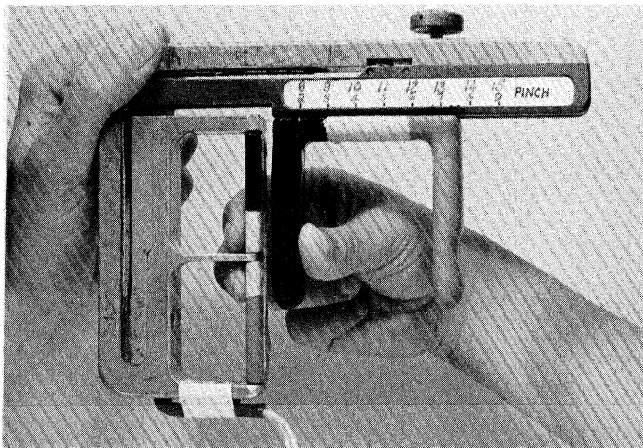
DESCRIPTION OF TEST: The anterior surface of the first two fingers (distal end of phalanges #2 and #3) are pressed in opposition to the anterior surface of the thumb tip (distal end of phalanx #1).

TEST POSITION: The thumb and first two fingers are flexed in the sagittal plane so that the thumb tip is opposite the first and second finger tips and one finger lies on each side of the distal handle brace. The remaining two fingers are flexed in the same plane into a tight fist.

ANTHROPOMETRIC MEASUREMENT: The length of the third phalanx is measured with an anthropometer.

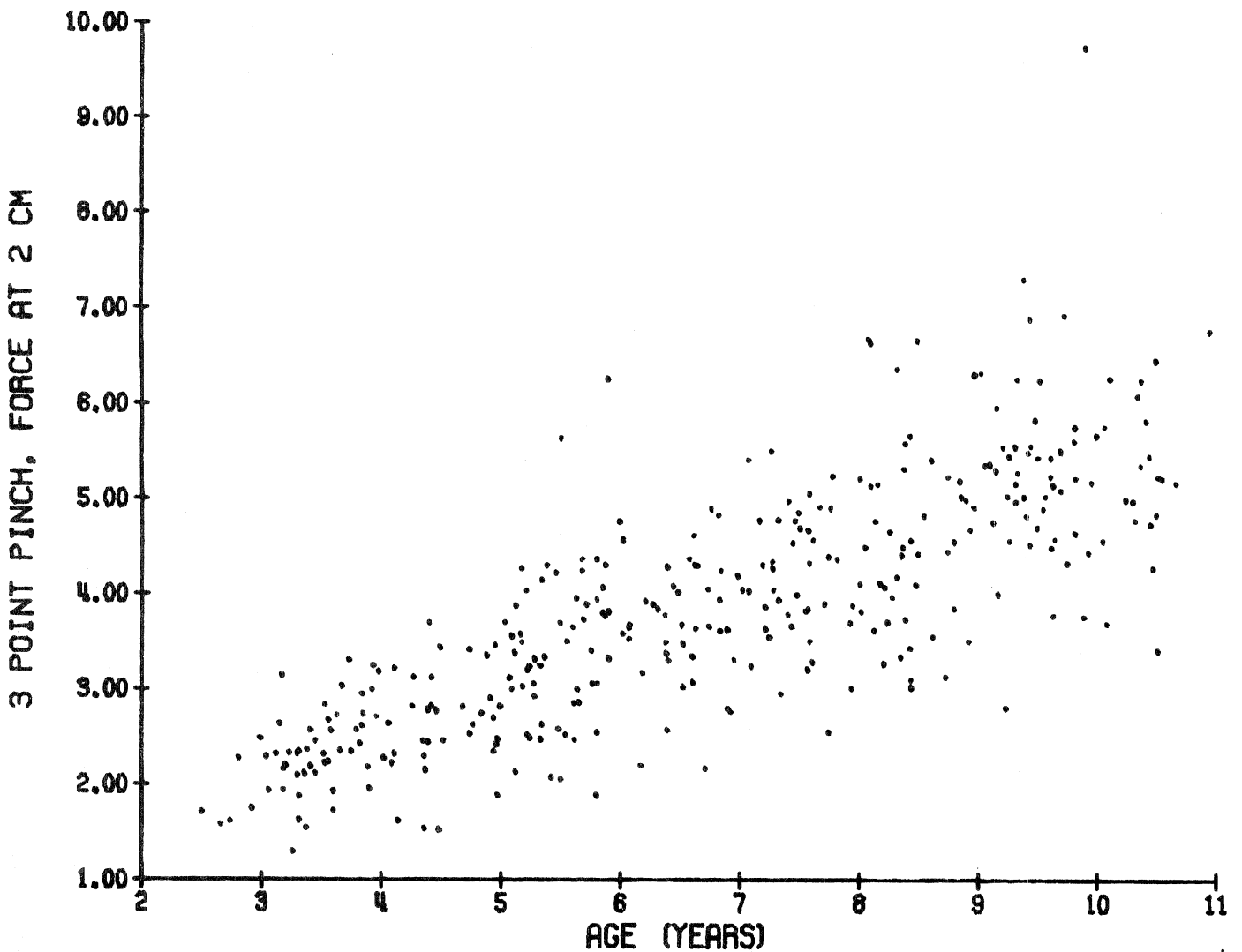
ADJUSTMENT OF EQUIPMENT: The pinch handle set is inserted into the transducer. The handle span (S) is adjusted to the proper test position.

INSTRUCTIONS TO SUBJECT: The child makes a fist and pinches the two plates together using his thumb and first two fingers.



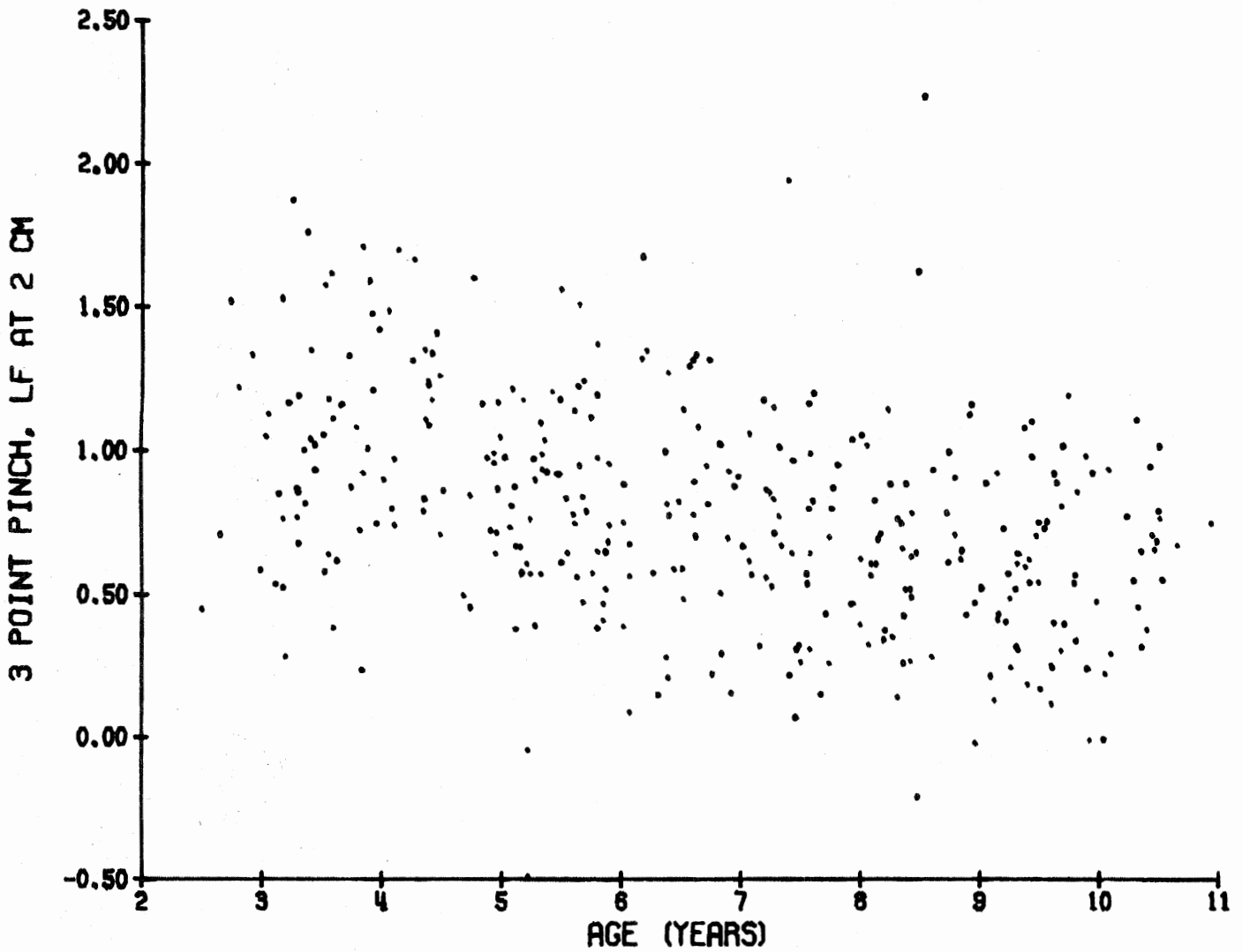
3 POINT PINCH, force at 2 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	2.1	0.4	1.3	1.4	2.2	2.6	3.1
3.5-4.5	44	2.6	0.5	1.5	1.6	2.6	3.3	3.7
4.5-5.5	44	3.1	0.6	1.9	2.1	3.0	4.2	4.3
5.5-6.5	49	3.6	0.8	1.9	2.1	3.7	4.7	6.2
6.5-7.5	46	4.0	0.7	2.2	2.8	4.0	4.9	5.5
7.5-8.5	52	4.4	1.0	2.5	3.0	4.3	6.4	6.7
8.5-9.5	42	5.0	0.9	2.8	3.2	5.0	6.3	7.3
9.5-10.5	44	5.2	1.0	3.4	3.7	5.1	6.7	9.7



3 POINT PINCH, force location at 2 cm  
(Males and Females)

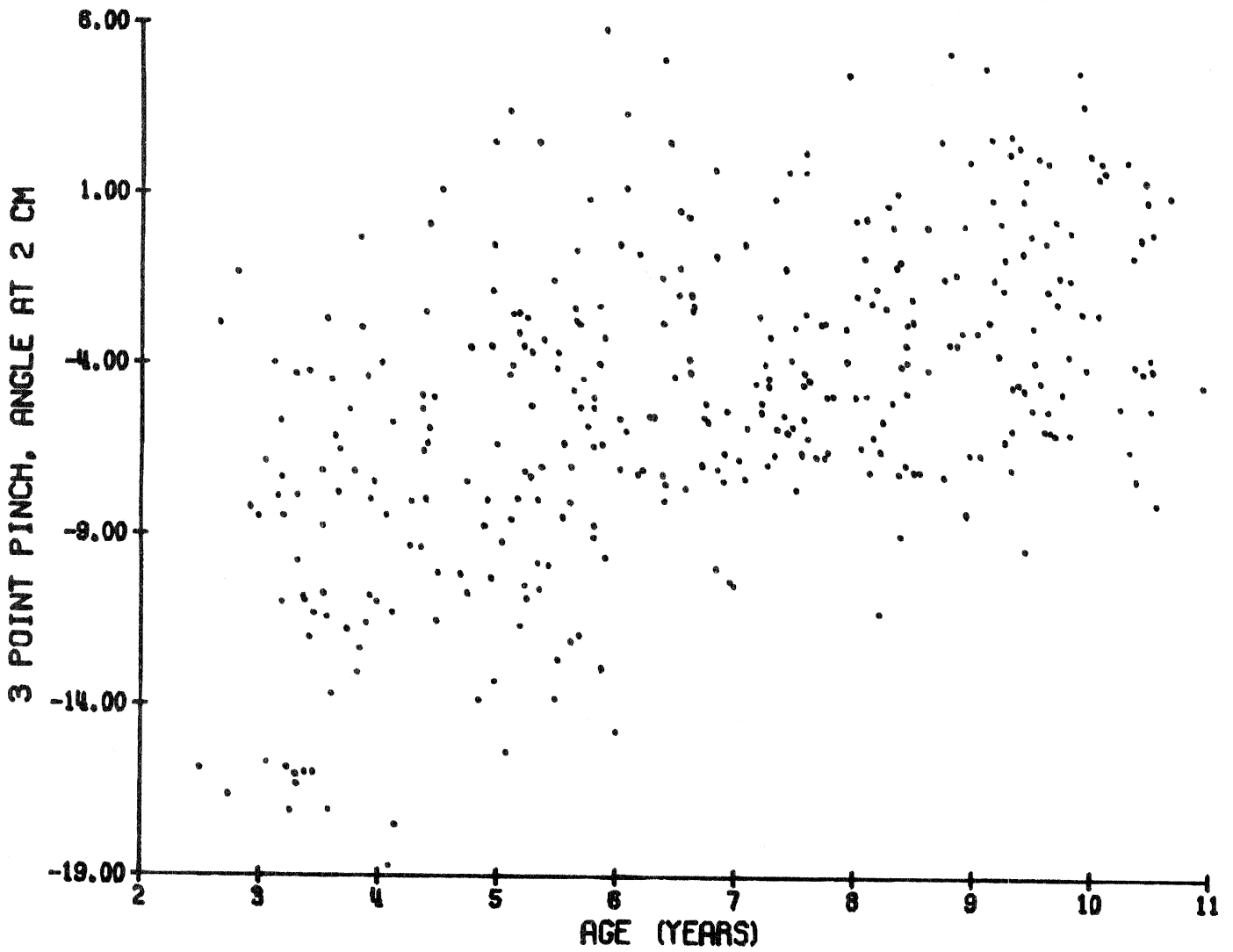
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	1.0	0.4	0.3	0.3	0.9	1.7	1.9
3.5-4.5	44	1.1	0.4	0.2	0.4	1.1	1.7	1.7
4.5-5.5	44	0.8	0.4	-0.5	0.0	0.9	1.2	1.6
5.5-6.5	48	0.8	0.4	0.1	0.2	0.8	1.5	1.7
6.5-7.5	46	0.8	0.4	0.1	0.2	0.8	1.3	1.9
7.5-8.5	52	0.6	0.3	-0.2	0.1	0.6	1.2	1.6
8.5-9.5	42	0.7	0.4	-0.0	0.1	0.6	1.1	2.2
9.5-10.5	44	0.6	0.3	-0.0	0.0	0.7	1.0	1.2





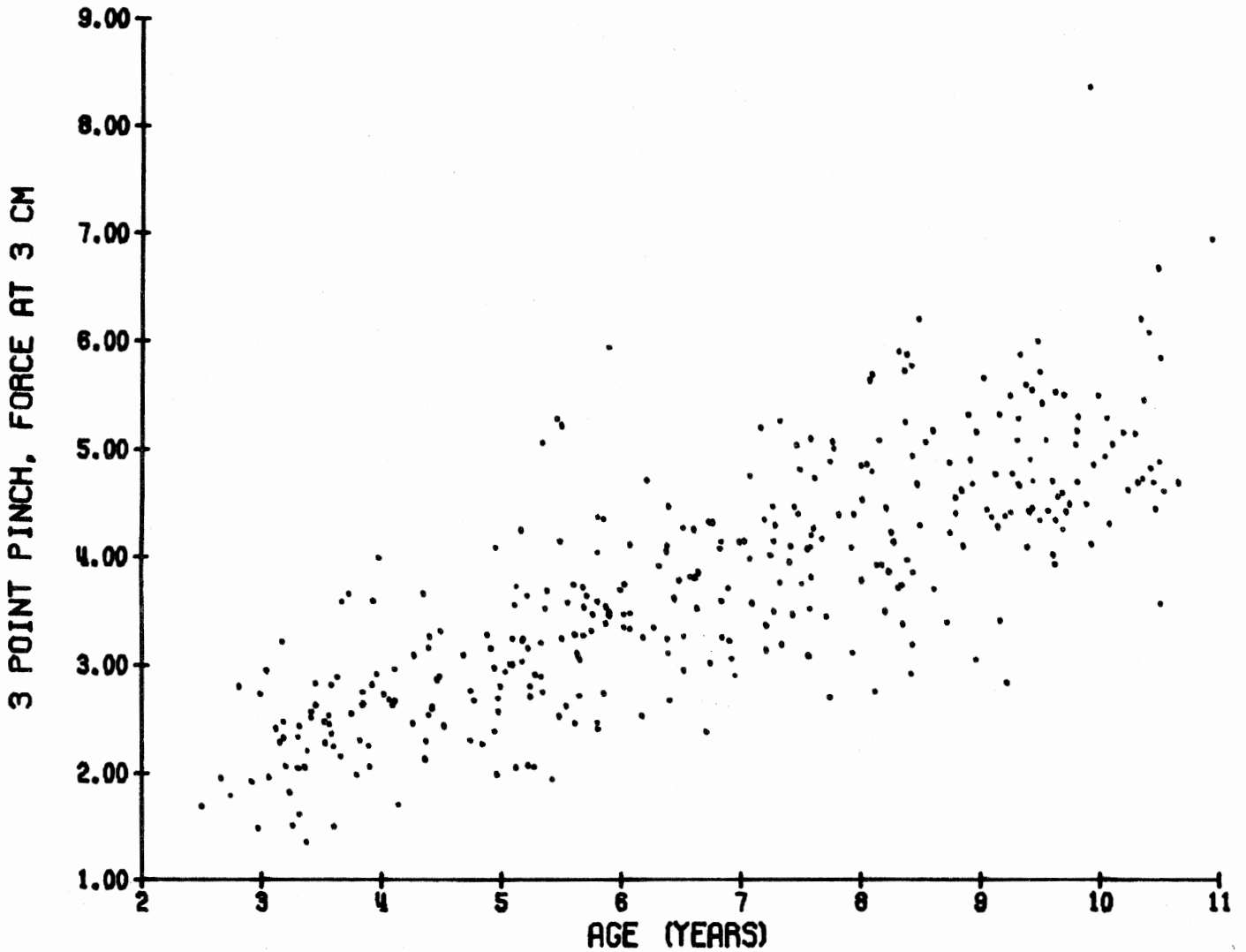
3 POINT PINCH, angle at 2 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	-10.3	4.8	-17.1	-16.9	-10.9	-3.3	-1.4
3.5-4.5	44	-8.2	4.2	-18.7	-17.4	-8.0	-2.6	0.0
4.5-5.5	44	-6.3	4.6	-15.4	-13.9	-7.2	2.2	3.4
5.5-6.5	49	-5.0	4.4	-14.8	-12.8	-5.6	2.9	5.7
6.5-7.5	46	-4.4	3.0	-10.5	-10.3	-5.2	0.7	1.6
7.5-8.5	52	-3.8	3.1	-11.3	-8.3	-4.3	1.2	4.4
8.5-9.5	42	-2.2	3.7	-9.5	-8.3	-2.8	2.6	5.1
9.5-10.5	44	-2.2	3.3	-8.1	-7.2	-2.5	2.1	4.5



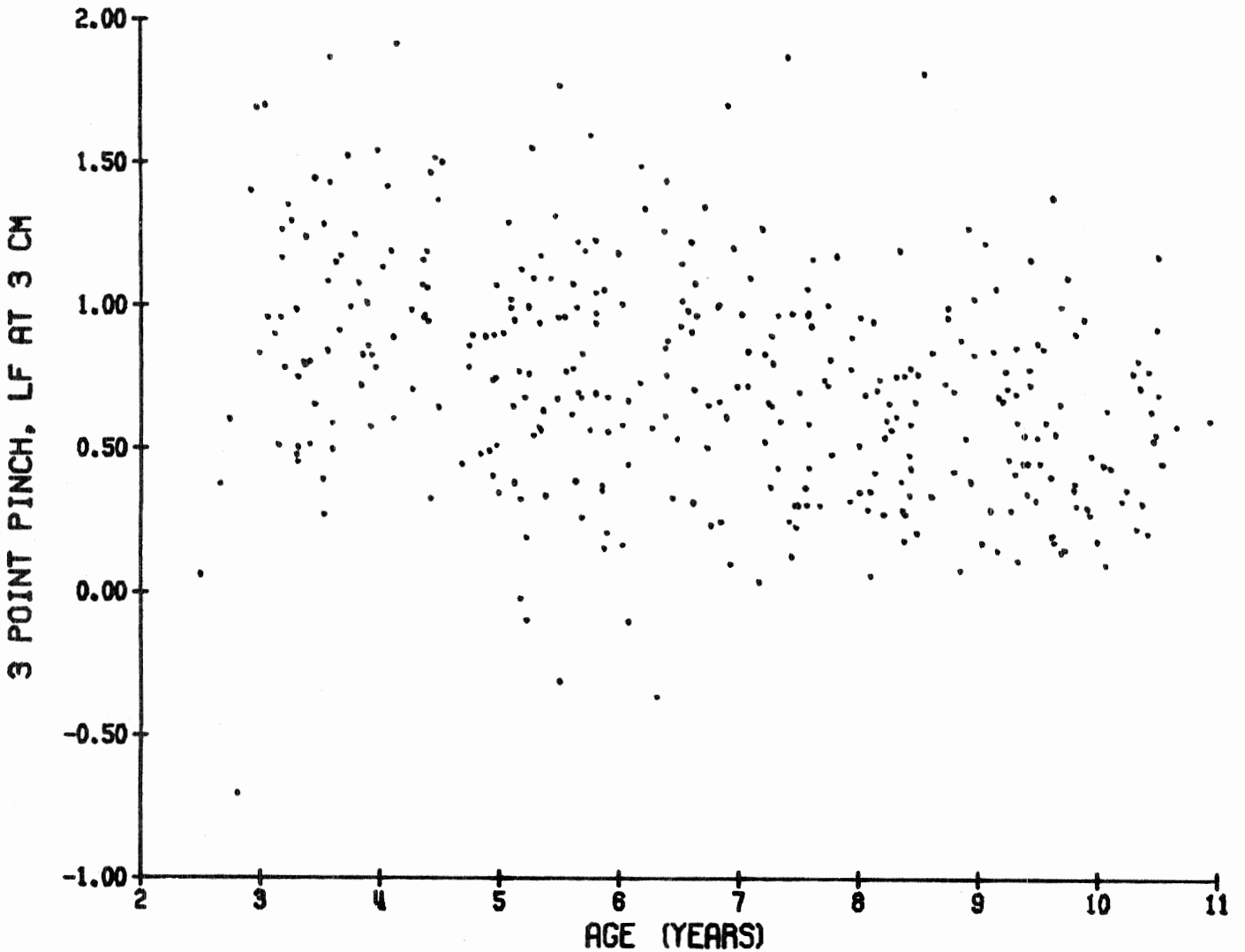
3 POINT PINCH, force at 3 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	2.2	0.5	1.4	1.4	2.1	2.9	3.2
3.5-4.5	45	2.7	0.5	1.5	1.8	2.6	3.6	4.0
4.5-5.5	44	3.0	0.7	1.9	2.0	2.9	4.2	5.3
5.5-6.5	49	3.5	0.7	2.4	2.5	3.5	4.6	6.0
6.5-7.5	46	3.9	0.6	2.4	2.9	3.9	5.0	5.3
7.5-8.5	52	4.4	0.9	2.7	2.9	4.2	5.8	6.2
8.5-9.5	42	4.7	0.7	2.9	3.1	4.7	5.7	6.0
9.5-10.5	45	5.0	0.9	3.6	4.0	4.8	6.6	8.4



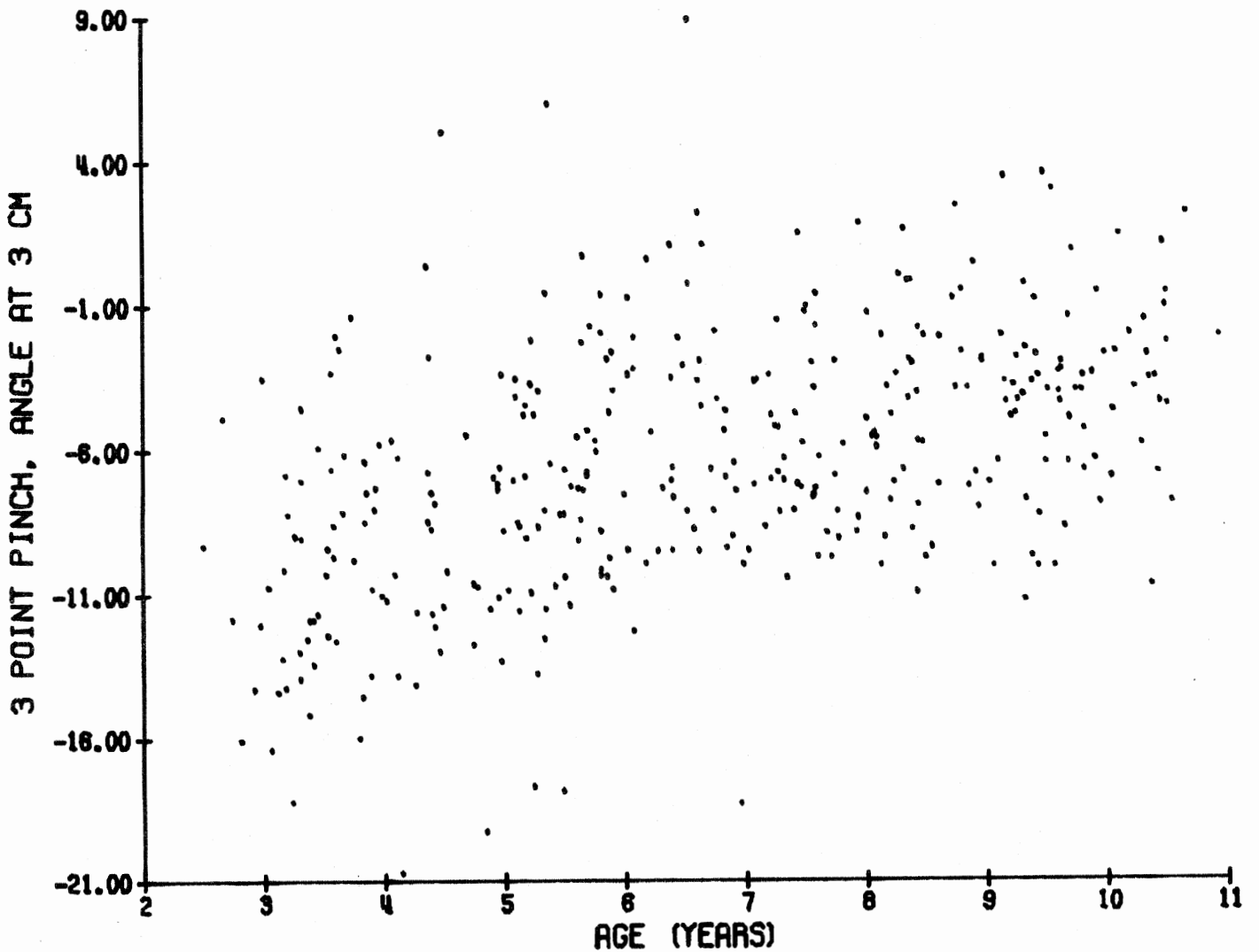
3 POINT PINCH, force location at 3 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	0.8	0.5	-0.7	-0.4	0.8	1.6	1.7
3.5-4.5	45	1.0	0.4	0.3	0.3	1.0	1.5	1.9
4.5-5.5	44	0.8	0.4	-0.1	0.0	0.8	1.3	1.5
5.5-6.5	49	0.7	0.5	-0.4	-0.2	0.7	1.5	1.8
6.5-7.5	46	0.8	0.4	0.0	0.1	0.7	1.3	1.9
7.5-8.5	52	0.6	0.3	0.1	0.2	0.6	1.1	1.2
8.5-9.5	42	0.7	0.4	0.1	0.1	0.7	1.2	1.8
9.5-10.5	45	0.5	0.3	0.1	0.1	0.5	1.1	1.4



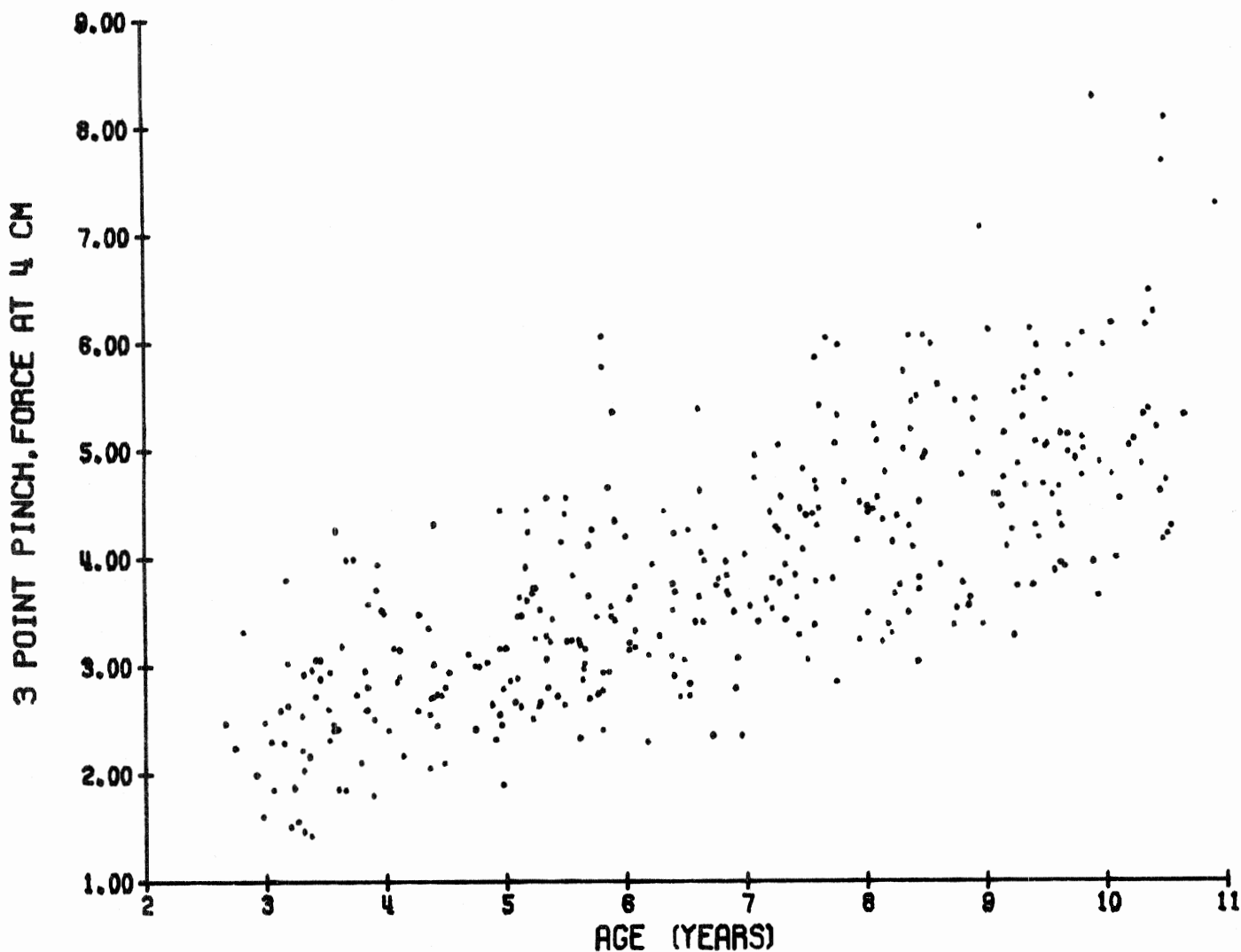
3 POINT PINCH, angle at 3 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	-11.2	3.8	-18.2	-17.4	-11.9	-4.7	-3.5
3.5-4.5	45	-8.7	4.6	-20.7	-15.6	-8.7	-1.5	5.1
4.5-5.5	44	-8.4	4.7	-19.3	-17.8	-8.5	-2.4	6.0
5.5-6.5	49	-5.9	3.6	-12.2	-11.1	-6.7	0.1	1.1
6.5-7.5	46	-5.5	4.2	-18.3	-10.3	-6.4	1.5	9.0
7.5-8.5	52	-5.2	3.3	-10.9	-9.8	-5.6	0.0	1.9
8.5-9.5	42	-4.2	3.6	-11.1	-10.0	-3.8	2.3	3.7
9.5-10.5	45	-3.6	3.0	-10.6	-9.6	-3.6	1.5	3.1



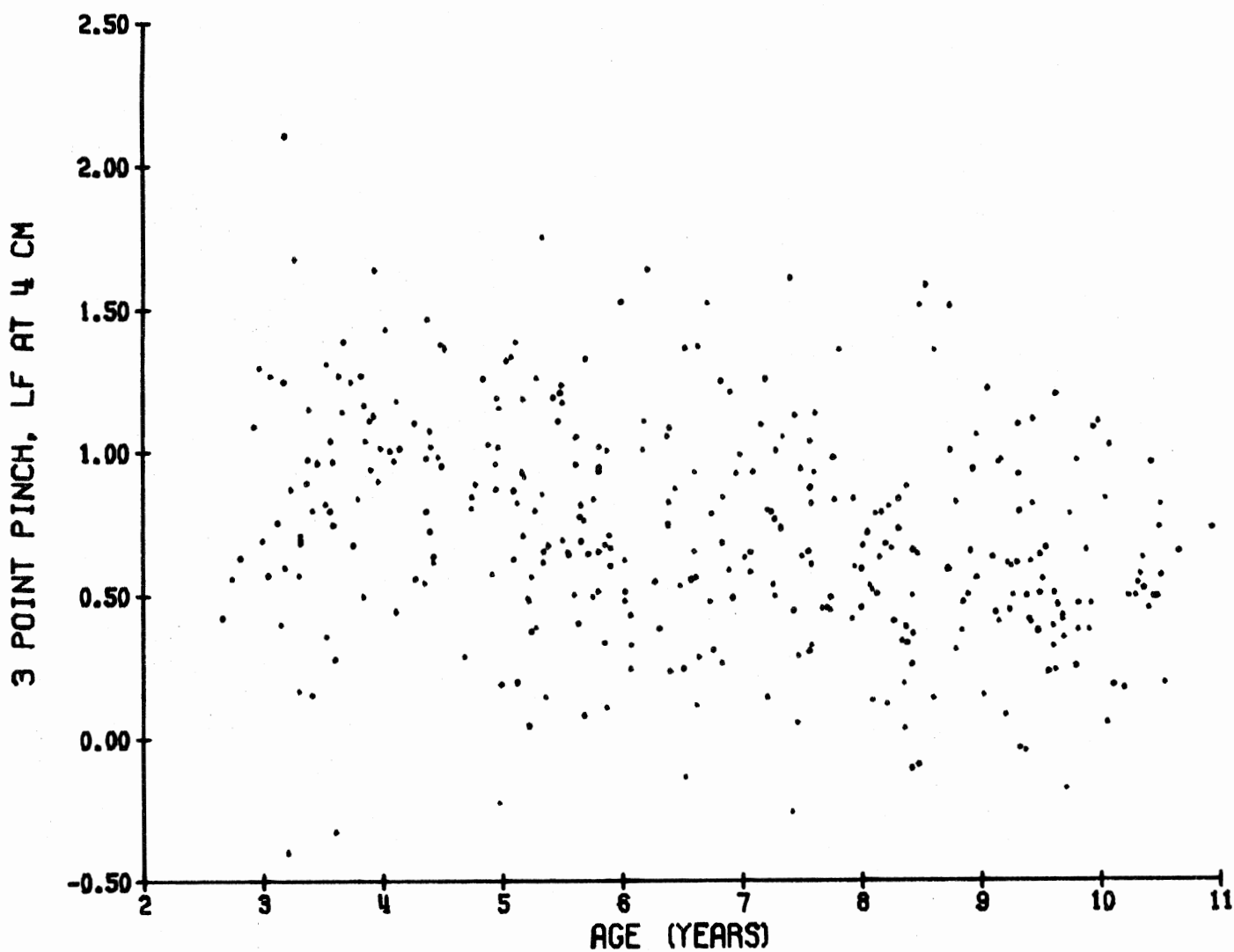
3 POINT PINCH, force at 4 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	2.4	0.6	1.4	1.4	2.3	3.2	3.8
3.5-4.5	45	2.9	0.6	1.8	1.8	2.7	4.0	4.3
4.5-5.5	44	3.2	0.6	1.9	2.3	3.1	4.4	4.5
5.5-6.5	49	3.5	0.8	2.3	2.4	3.2	5.0	6.0
6.5-7.5	46	3.8	0.7	2.3	2.5	3.8	4.9	5.4
7.5-8.5	52	4.4	0.9	2.8	3.0	4.4	6.0	6.0
8.5-9.5	42	4.8	0.9	3.3	3.4	4.7	6.1	7.0
9.5-10.5	45	5.2	1.1	3.6	3.9	5.0	7.5	8.2



3 POINT PINCH, force location at 4 cm  
(Males and Females)

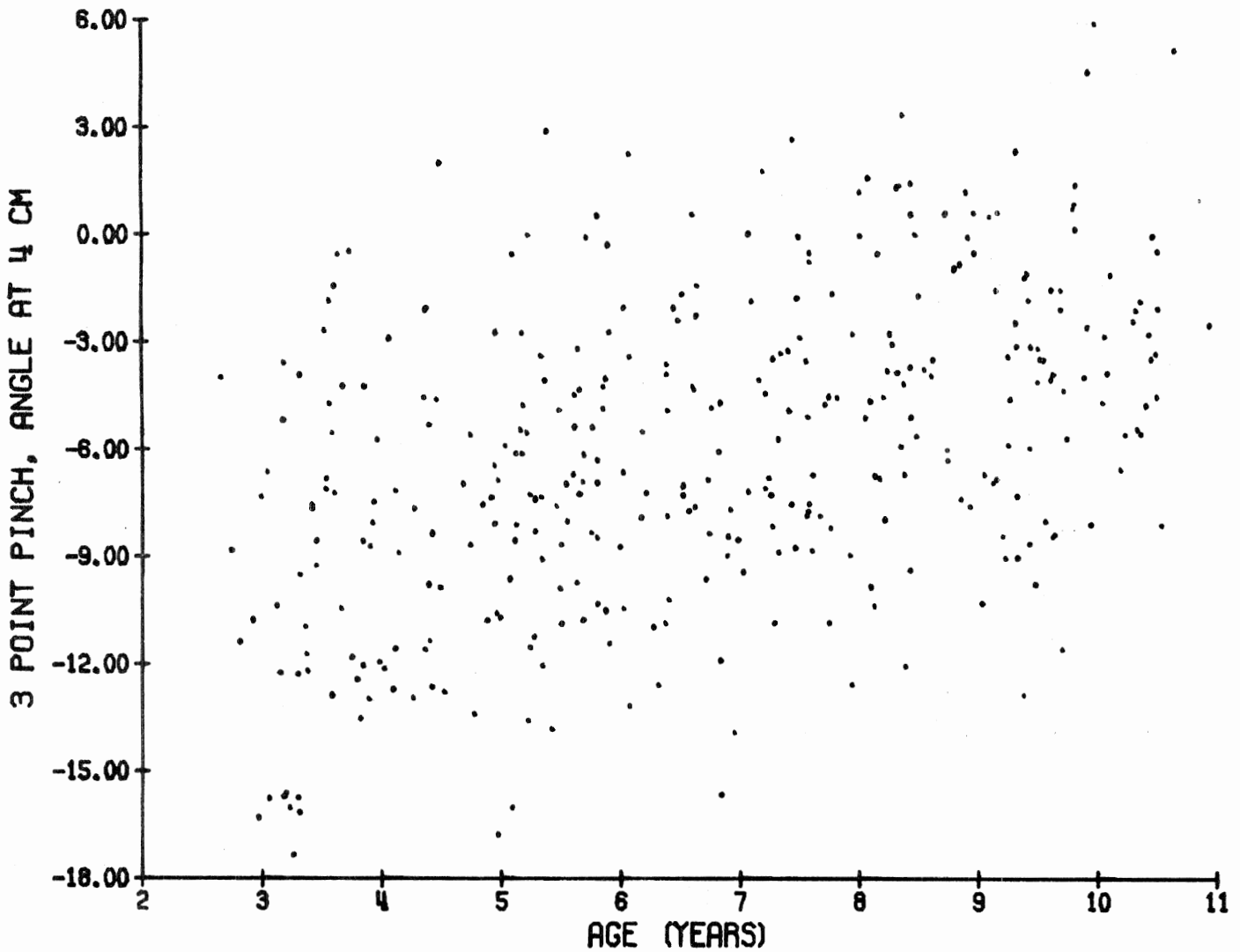
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	0.8	0.5	-0.4	-0.2	0.7	1.5	2.1
3.5-4.5	45	0.9	0.4	-0.3	0.3	1.0	1.4	1.6
4.5-5.5	44	0.8	0.4	-0.2	0.1	0.9	1.4	1.8
5.5-6.5	49	0.7	0.3	0.1	0.2	0.7	1.3	1.6
6.5-7.5	46	0.7	0.4	-0.3	-0.1	0.7	1.4	1.6
7.5-8.5	52	0.6	0.3	-0.1	-0.0	0.6	1.1	1.5
8.5-9.5	42	0.7	0.4	-0.0	-0.0	0.6	1.4	1.6
9.5-10.5	45	0.5	0.3	-0.2	0.1	0.5	1.1	1.2



3 POINT PINCH, angle at 4 cm  
(Males and Females)

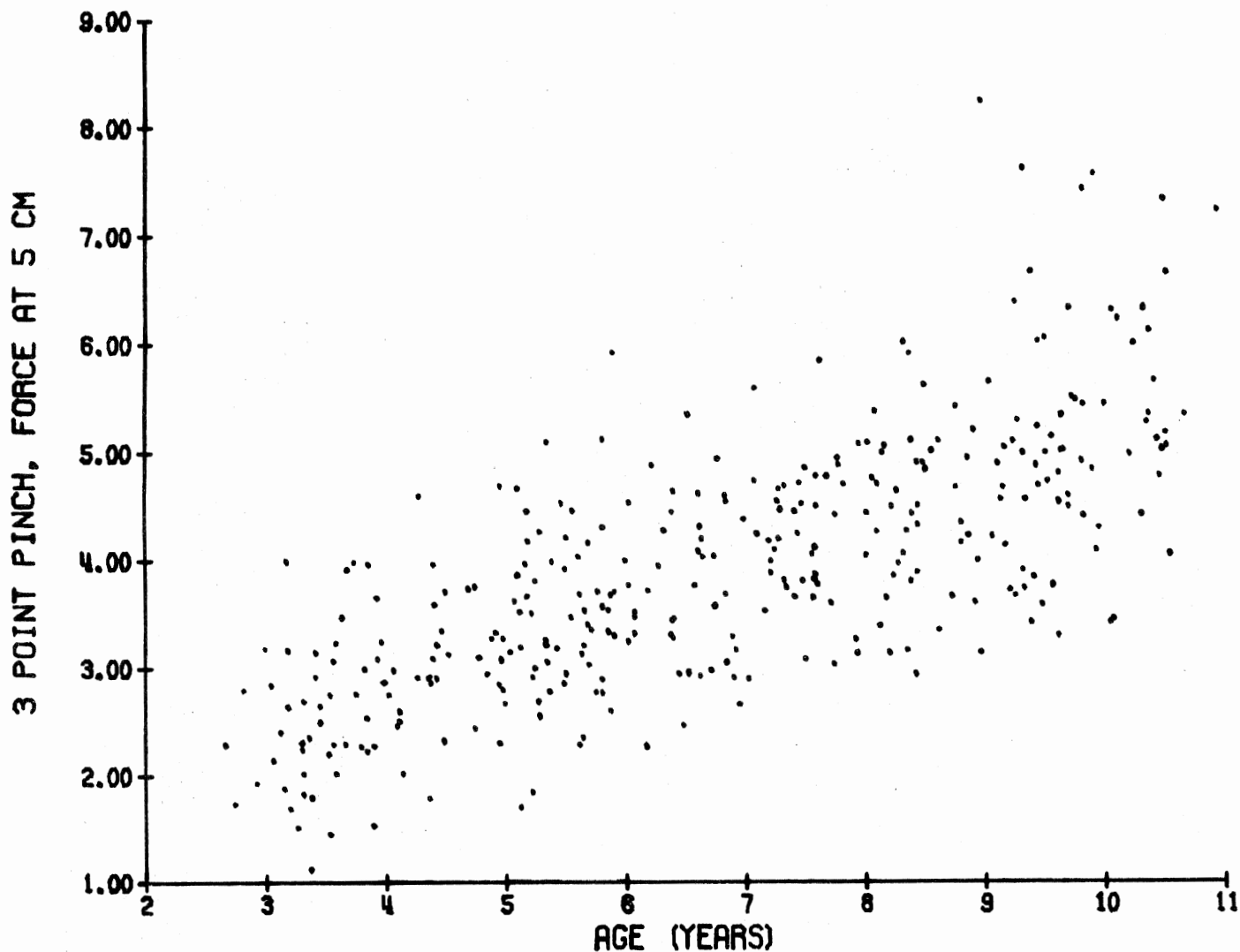
(Degrees)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	-10.8	4.2	-17.4	-16.9	-11.0	-4.0	-3.6
3.5-4.5	45	-7.6	4.2	-13.5	-13.0	-7.9	-0.8	2.0
4.5-5.5	44	-7.8	4.1	-16.8	-15.6	-7.6	-1.0	2.8
5.5-6.5	49	-6.5	3.6	-13.2	-12.1	-6.8	-0.2	2.2
6.5-7.5	46	-5.9	3.9	-15.7	-13.3	-6.9	0.3	2.6
7.5-8.5	52	-4.5	3.9	-12.6	-11.4	-4.6	1.3	3.3
8.5-9.5	42	-4.2	3.7	-12.9	-10.3	-3.8	0.5	2.2
9.5-10.5	45	-3.2	3.5	-11.6	-8.5	-3.6	3.6	5.8



3 POINT PINCH, force at 5 cm (Kgf)  
(Males and Females)

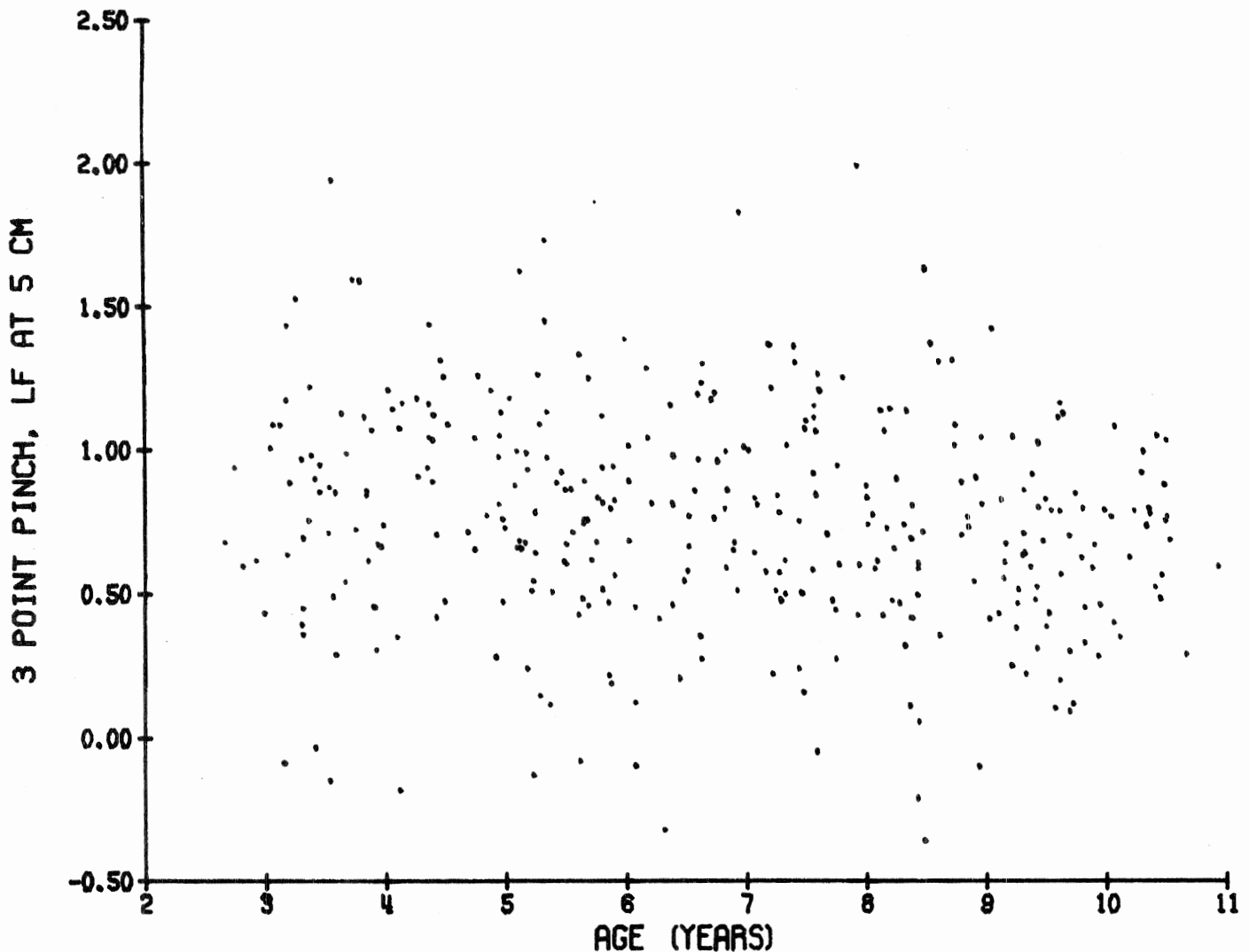
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	26	2.4	0.6	1.1	1.2	2.3	3.2	4.0
3.5-4.5	43	2.9	0.7	1.5	1.6	2.9	4.0	4.6
4.5-5.5	44	3.4	0.7	1.7	1.9	3.2	4.6	5.1
5.5-6.5	49	3.6	0.7	2.3	2.3	3.5	4.8	5.9
6.5-7.5	46	4.0	0.7	2.7	2.9	4.1	4.9	5.6
7.5-8.5	52	4.4	0.8	3.0	3.1	4.4	5.7	6.0
8.5-9.5	42	4.8	1.1	3.2	3.4	4.7	6.7	8.3
9.5-10.5	45	5.3	1.0	3.3	3.5	5.1	7.3	7.6





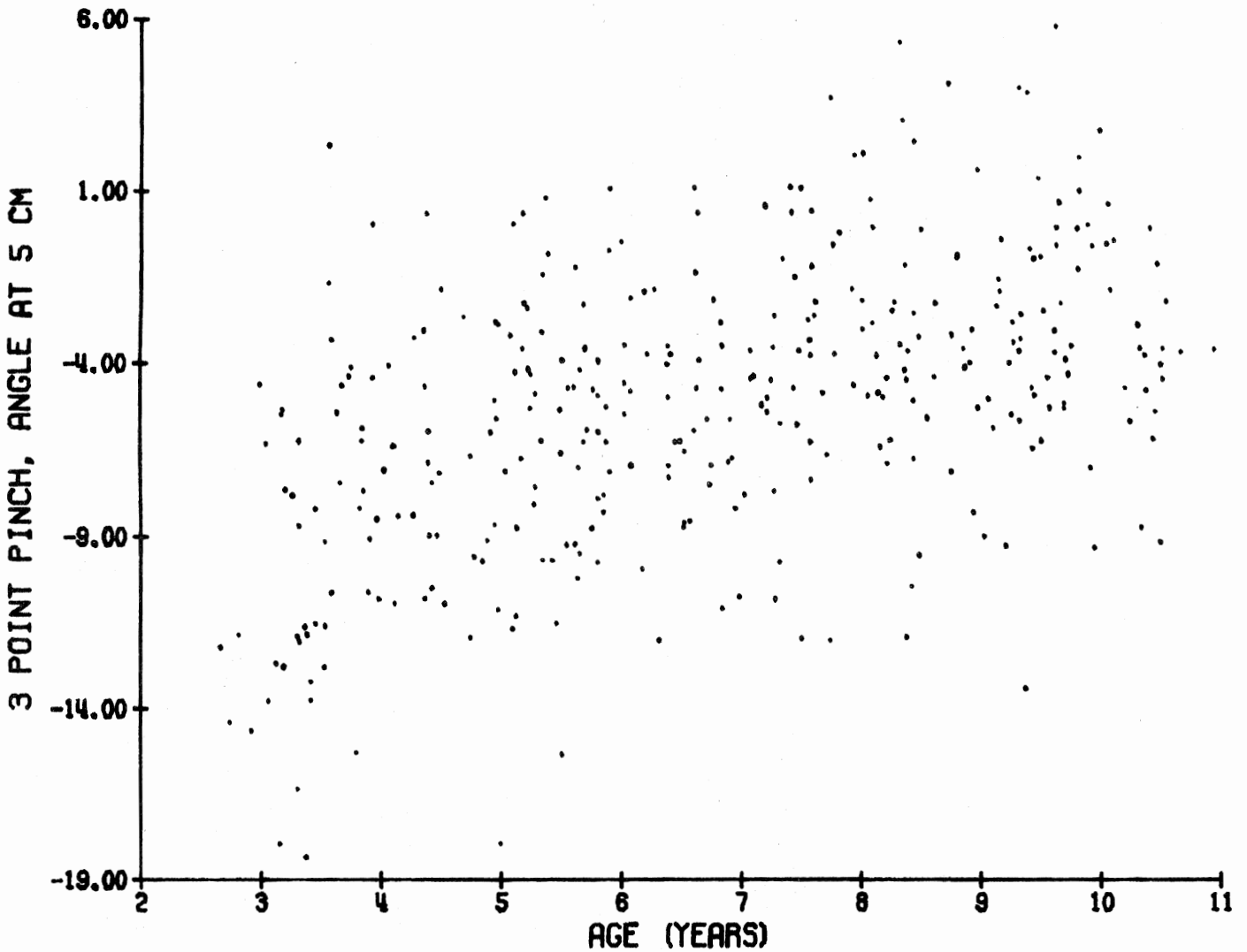
3 POINT PINCH, force location at 5 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	26	0.8	0.4	-0.1	-0.1	0.9	1.4	1.5
3.5-4.5	43	0.9	0.4	-0.2	-0.1	0.9	1.6	1.9
4.5-5.5	44	0.8	0.4	-0.1	0.1	0.8	1.4	1.7
5.5-6.5	49	0.7	0.4	-0.3	-0.1	0.7	1.3	1.4
6.5-7.5	46	0.8	0.4	0.2	0.2	0.8	1.3	1.8
7.5-8.5	52	0.7	0.4	-0.4	-0.1	0.7	1.3	2.0
8.5-9.5	42	0.7	0.3	-0.1	0.2	0.7	1.3	1.4
9.5-10.5	45	0.6	0.3	0.1	0.1	0.7	1.1	1.2



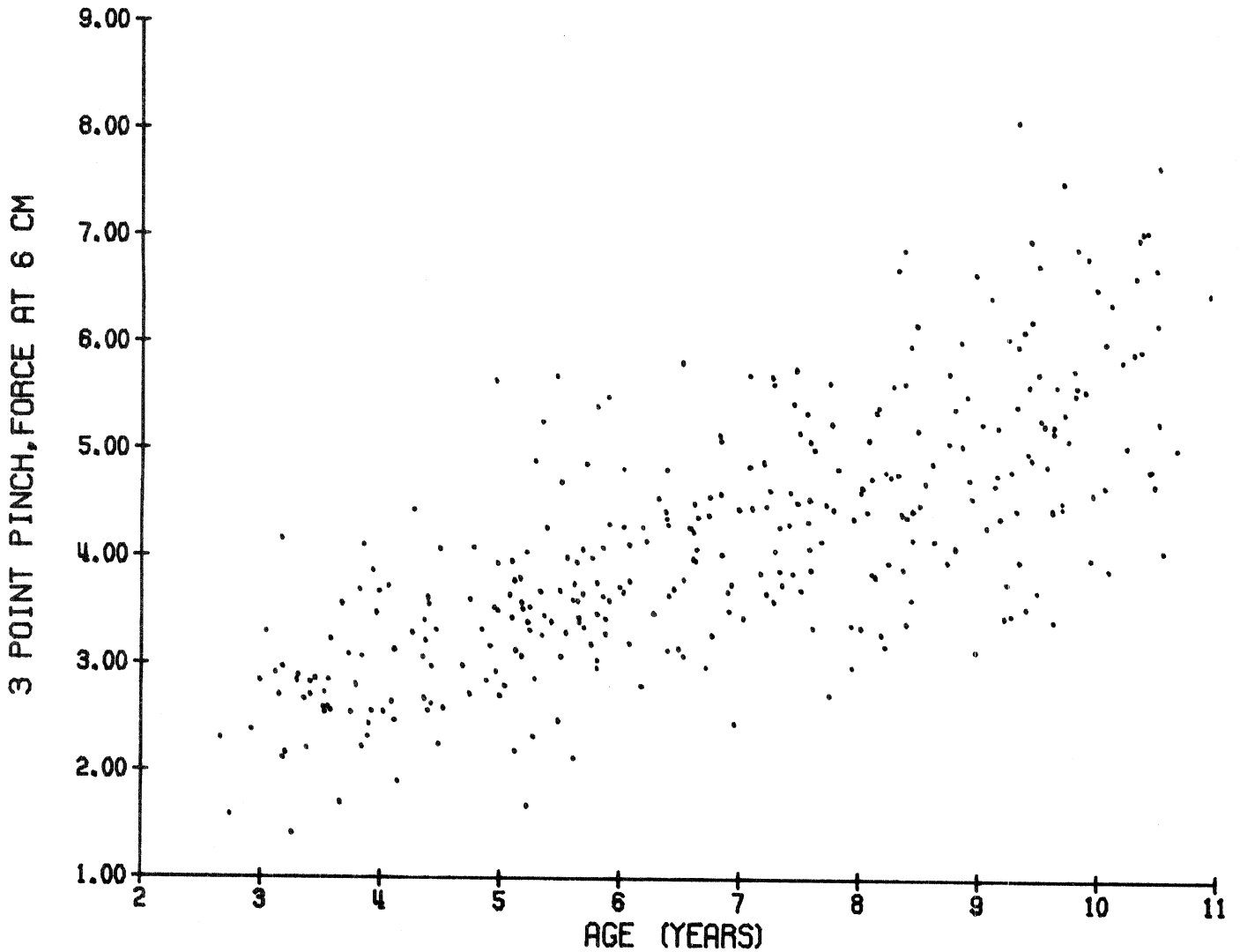
3 POINT PINCH, angle at 5 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	26	-11.2	3.8	-18.4	-18.2	-11.9	-5.4	-4.6
3.5-4.5	43	-6.7	3.7	-15.3	-12.6	-7.1	-0.2	2.3
4.5-5.5	44	-6.2	4.0	-17.9	-11.9	-6.0	-0.1	0.8
5.5-6.5	49	-5.6	3.1	-15.3	-11.2	-5.3	-0.9	1.1
6.5-7.5	46	-4.8	3.3	-11.0	-10.8	-4.9	1.0	1.2
7.5-8.5	52	-3.4	3.9	-12.0	-11.9	-3.4	2.8	5.4
8.5-9.5	42	-3.3	3.6	-13.4	-9.2	-3.5	3.7	4.2
9.5-10.5	45	-2.7	3.1	-9.2	-9.0	-3.5	1.8	5.9



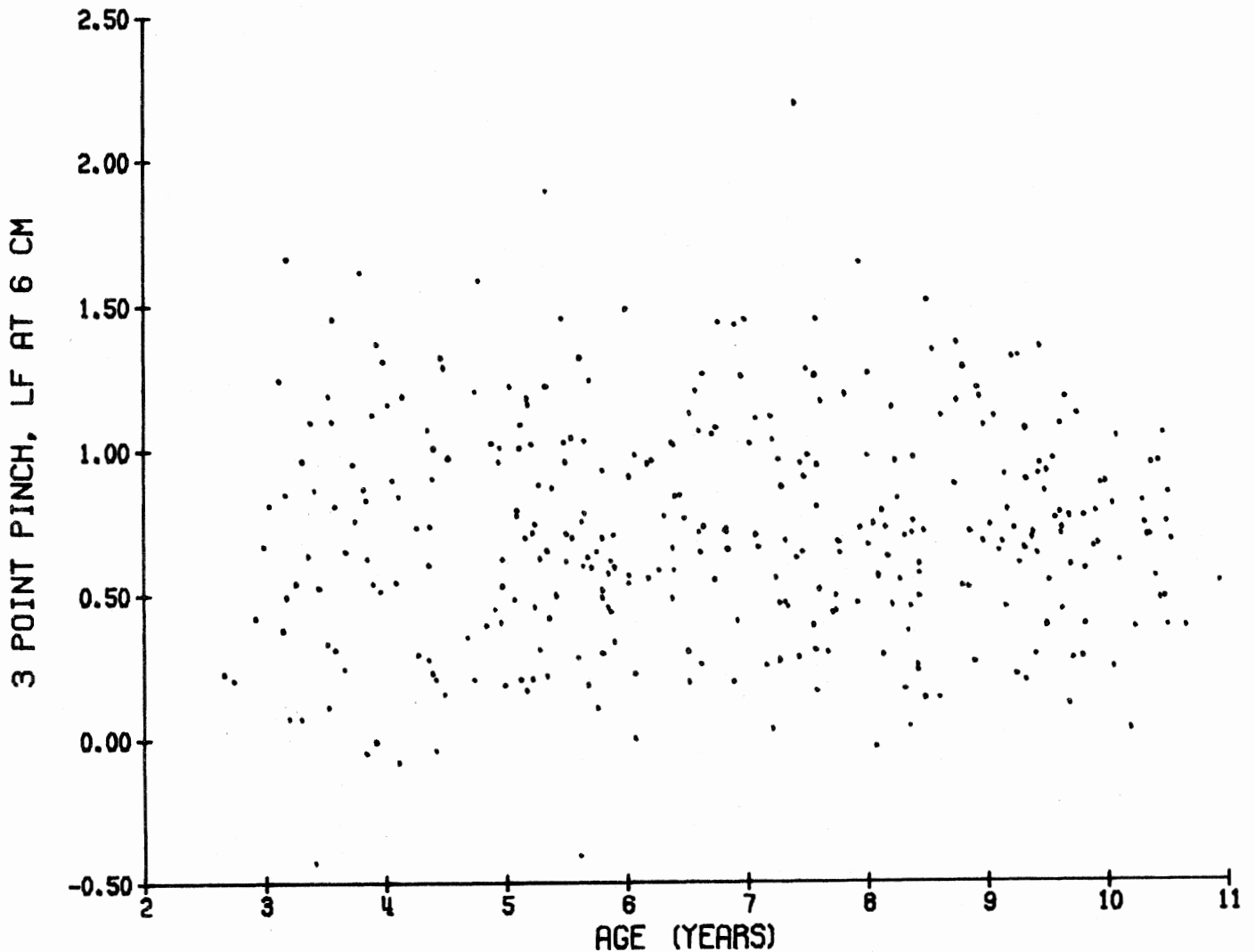
**3 POINT PINCH, force at 6 cm (Kgf)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	19	2.6	0.6	1.4	**	2.7	**	4.2
3.5-4.5	42	3.0	0.6	1.7	1.9	2.8	4.0	4.4
4.5-5.5	43	3.5	0.8	1.7	2.2	3.4	5.2	5.7
5.5-6.5	49	3.8	0.7	2.1	2.9	3.7	4.8	5.5
6.5-7.5	46	4.3	0.8	2.4	3.0	4.3	5.7	5.8
7.5-8.5	52	4.5	0.9	2.7	3.1	4.4	6.0	6.9
8.5-9.5	42	5.0	1.1	3.1	3.4	4.9	6.7	8.1
9.5-10.5	45	5.5	1.0	3.4	3.9	5.3	7.0	7.6



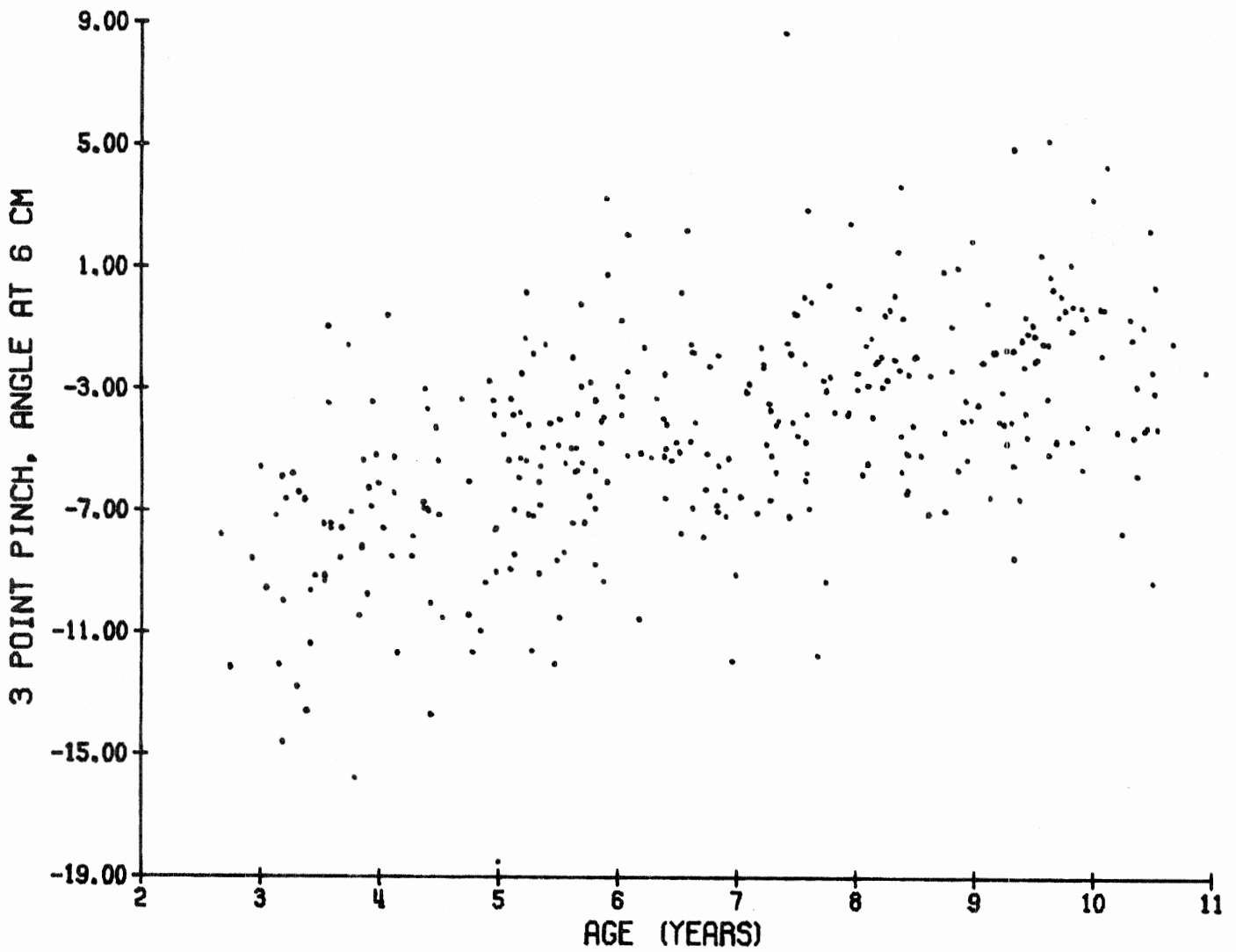
3 POINT PINCH, force location at 6 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	19	0.6	0.5	-0.4	**	0.5	**	1.7
3.5-4.5	42	0.7	0.5	-0.1	-0.0	0.7	1.4	1.6
4.5-5.5	43	0.8	0.4	0.2	0.2	0.7	1.4	1.9
5.5-6.5	49	0.7	0.3	-0.4	0.1	0.6	1.2	1.5
6.5-7.5	46	0.8	0.4	0.0	0.2	0.7	1.4	2.2
7.5-8.5	52	0.7	0.4	-0.0	0.1	0.6	1.3	1.7
8.5-9.5	42	0.8	0.3	0.1	0.2	0.7	1.3	1.4
9.5-10.5	45	0.7	0.3	0.0	0.2	0.7	1.1	1.2



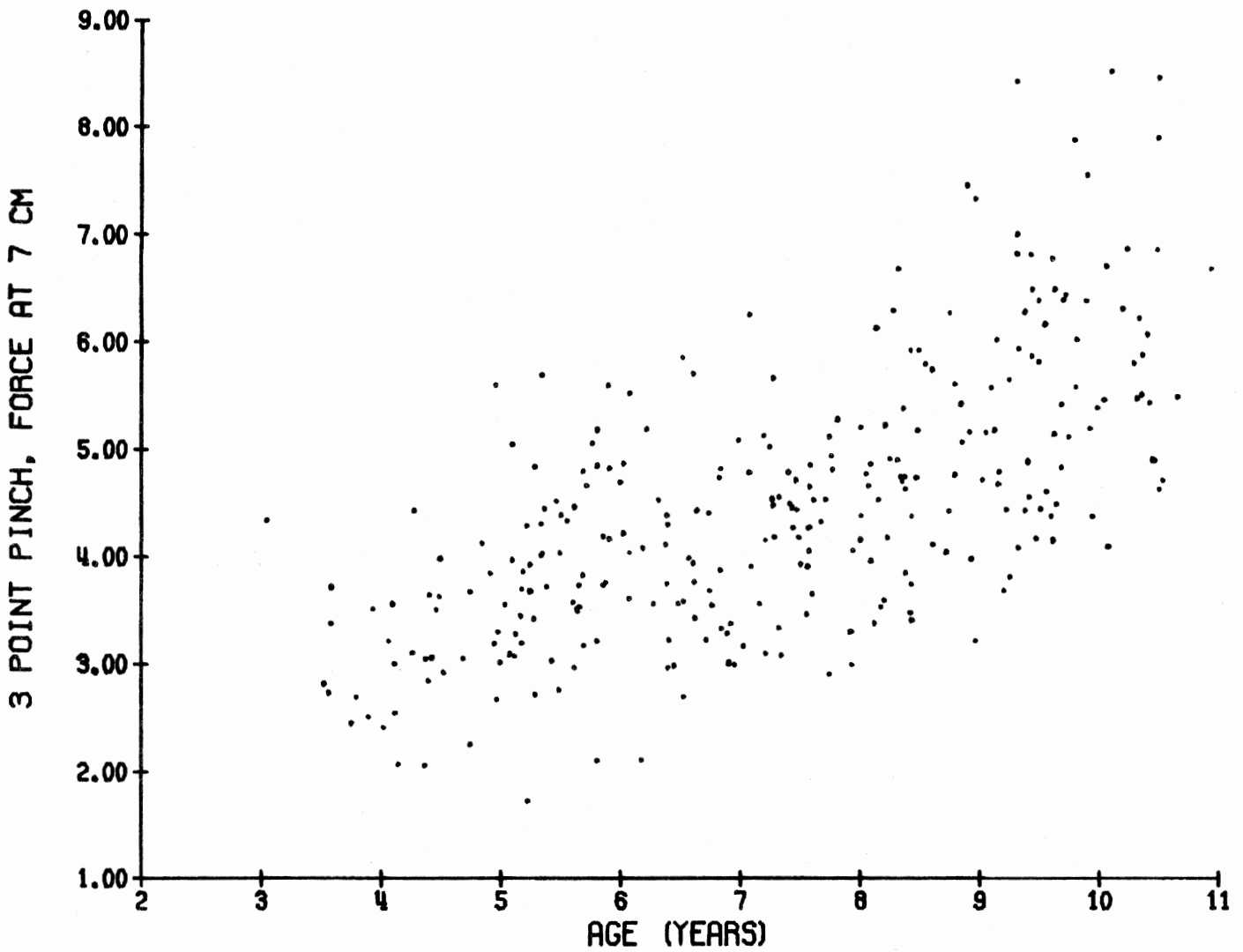
3 POINT PINCH, angle at 6 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	19	-9.2	2.9	-14.6	**	-9.4	**	-5.6
3.5-4.5	42	-7.0	3.0	-15.8	-13.5	-7.1	-1.7	-0.6
4.5-5.5	43	-6.4	3.6	-18.5	-12.0	-6.0	-1.6	0.2
5.5-6.5	49	-4.5	2.8	-10.5	-10.0	-4.9	0.3	3.2
6.5-7.5	46	-4.1	3.3	-11.9	-8.7	-4.2	-0.1	8.6
7.5-8.5	52	-2.9	2.9	-11.8	-7.9	-2.7	1.8	3.6
8.5-9.5	42	-3.0	2.6	-8.5	-7.1	-3.1	0.9	4.8
9.5-10.5	45	-1.9	2.9	-9.3	-7.2	-1.5	2.9	5.1



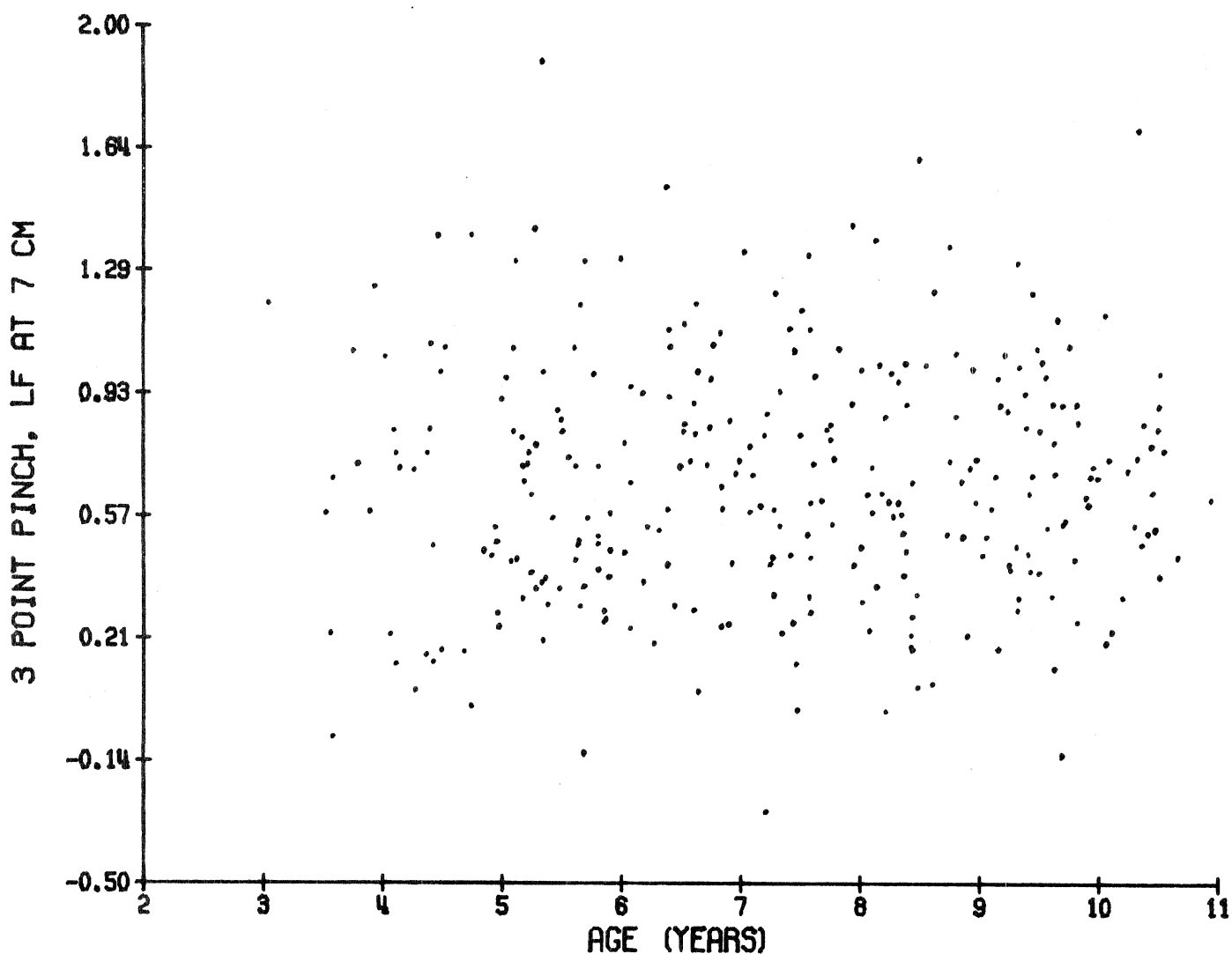
3 POINT PINCH, force at 7 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	1	4.3	**	4.3	**	4.3	**	4.3
3.5-4.5	25	3.1	0.6	2.1	2.1	3.1	3.9	4.4
4.5-5.5	38	3.7	0.8	1.7	2.2	3.7	5.1	5.7
5.5-6.5	43	4.0	0.8	2.1	2.2	4.1	5.2	5.6
6.5-7.5	46	4.2	0.8	2.7	3.0	4.2	5.7	6.3
7.5-8.5	52	4.5	0.8	2.9	3.2	4.5	6.0	6.7
8.5-9.5	41	5.4	1.2	3.2	3.7	5.2	7.3	8.5
9.5-10.5	45	5.8	1.1	4.1	4.2	5.6	7.9	8.6



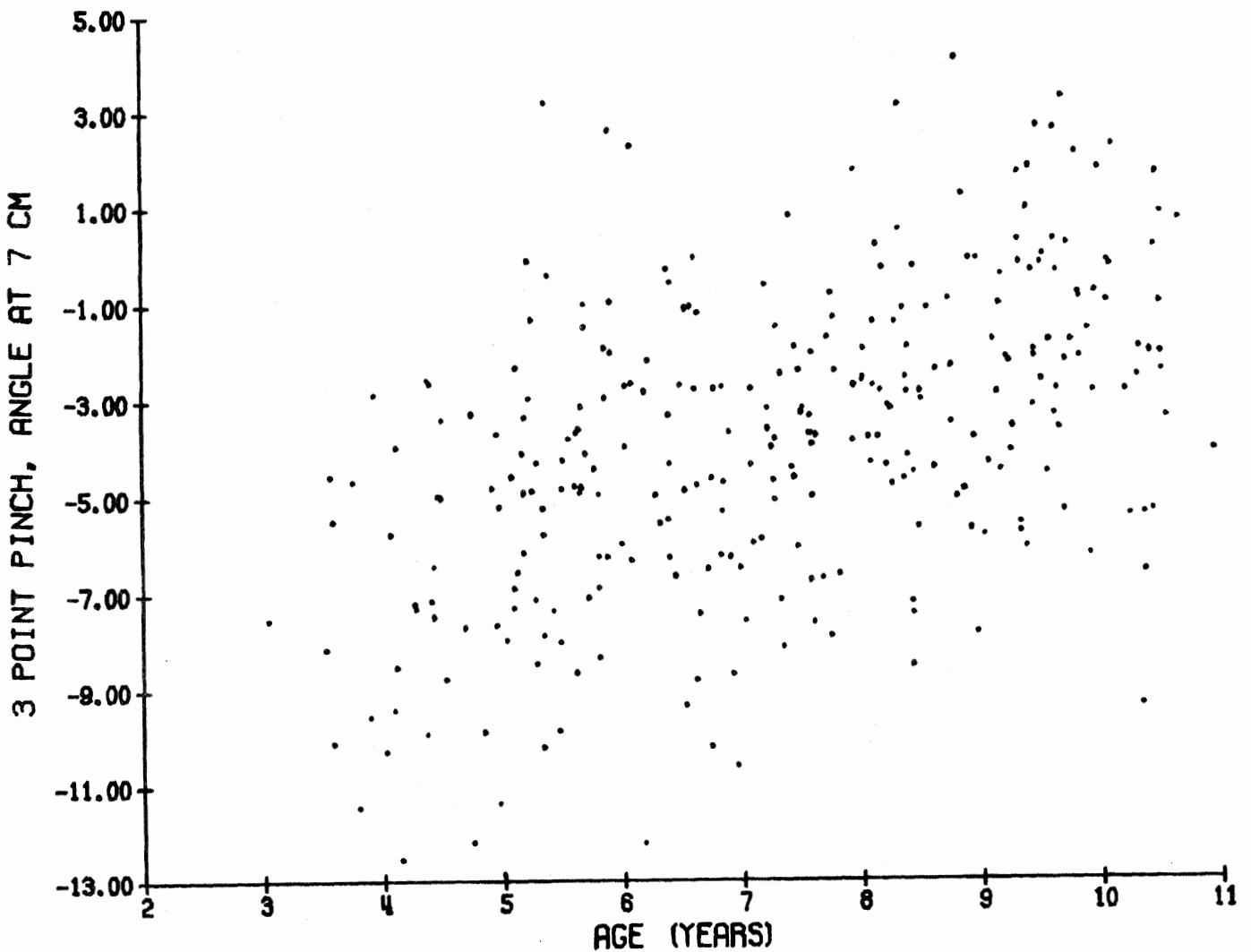
3 POINT PINCH, force location at 7 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	1	1.2	**	1.2	**	1.2	**	1.2
3.5-4.5	25	0.6	0.4	-0.1	-0.0	0.7	1.2	1.4
4.5-5.5	38	0.7	0.4	0.0	0.2	0.6	1.4	1.9
5.5-6.5	43	0.6	0.3	-0.1	0.2	0.5	1.3	1.5
6.5-7.5	46	0.7	0.4	-0.3	0.0	0.7	1.2	1.3
7.5-8.5	52	0.7	0.4	0.0	0.1	0.6	1.3	1.6
8.5-9.5	41	0.7	0.3	0.1	0.2	0.7	1.2	1.4
9.5-10.5	45	0.7	0.3	-0.1	0.1	0.7	1.1	1.7



3 POINT PINCH, angle at 7 cm (Degrees)  
(Males and Females)

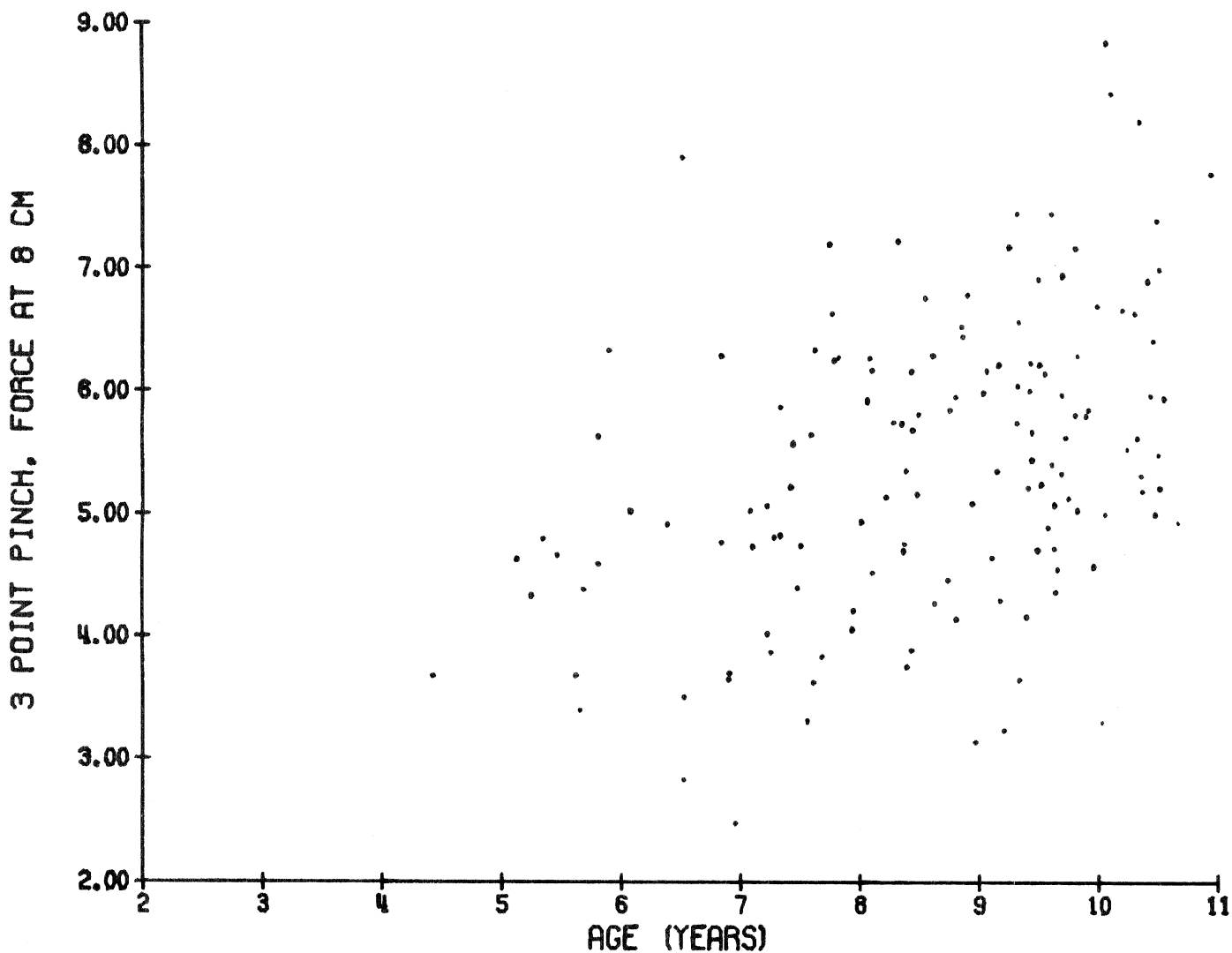
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	1	-7.5	**	-7.5	**	-7.5	**	-7.5
3.5-4.5	25	-6.8	2.9	-12.5	-12.3	-7.2	-2.7	-2.6
4.5-5.5	38	-6.0	3.4	-12.9	-12.2	-6.1	-0.3	3.2
5.5-6.5	43	-4.0	2.8	-12.2	-8.6	-4.1	-0.3	2.6
6.5-7.5	46	-4.6	2.7	-10.6	-9.9	-4.6	-0.7	0.9
7.5-8.5	52	-3.2	2.4	-8.5	-7.7	-3.1	0.4	3.2
8.5-9.5	41	-2.1	2.7	-7.8	-6.0	-2.2	1.9	4.1
9.5-10.5	45	-1.7	2.7	-9.3	-6.4	-1.8	2.3	3.3





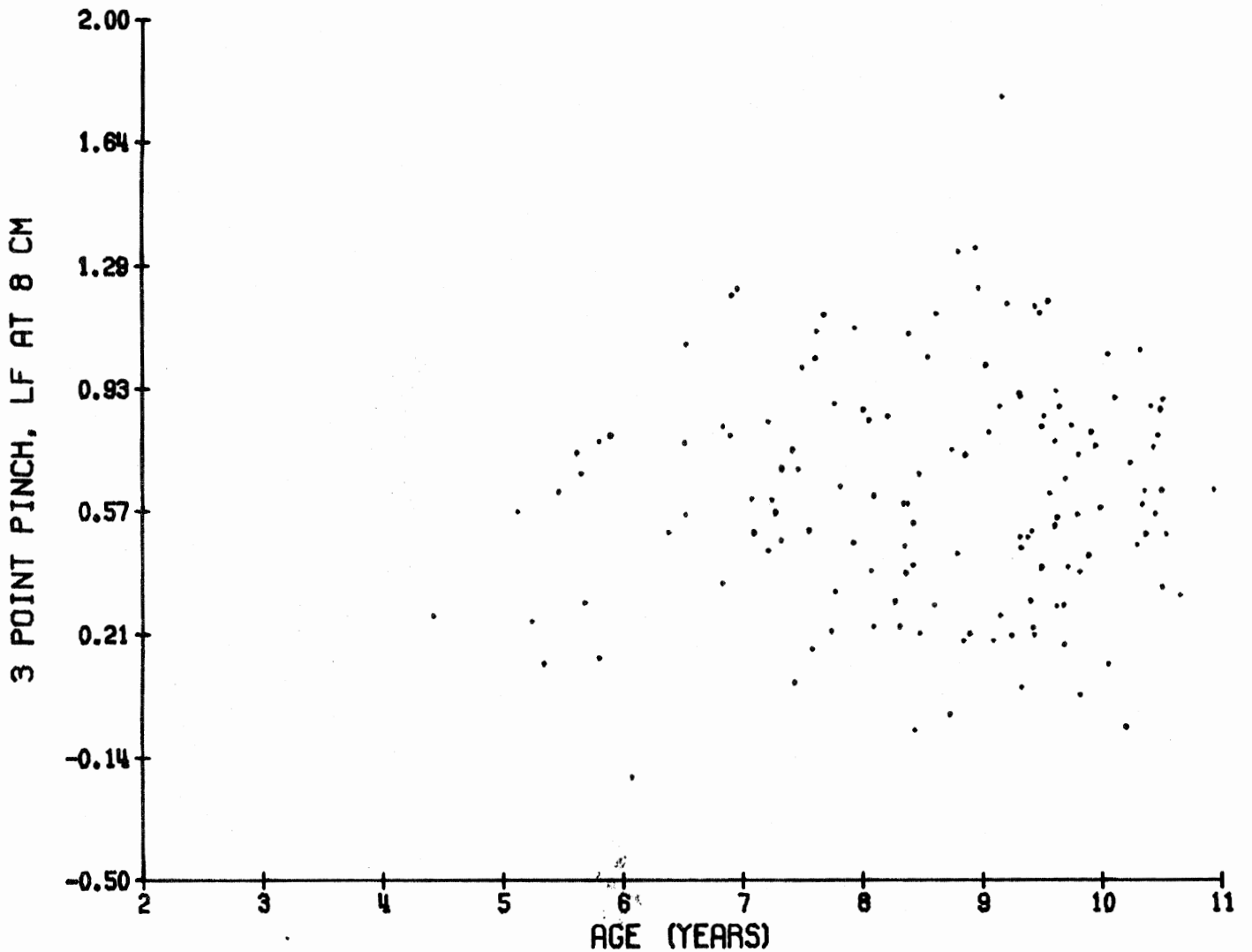
3 POINT PINCH, force at 8 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	3.7	**	3.7	**	3.7	**	3.7
4.5-5.5	4	4.6	0.2	4.3	**	4.6	**	4.8
5.5-6.5	8	4.7	1.0	3.4	**	4.6	**	6.3
6.5-7.5	20	4.7	1.2	2.5	**	4.7	**	7.9
7.5-8.5	29	5.3	1.1	3.3	3.4	5.5	6.9	7.2
8.5-9.5	34	5.5	1.1	3.1	3.2	5.8	7.0	7.4
9.5-10.5	43	6.0	1.1	4.4	4.5	5.7	8.1	8.8



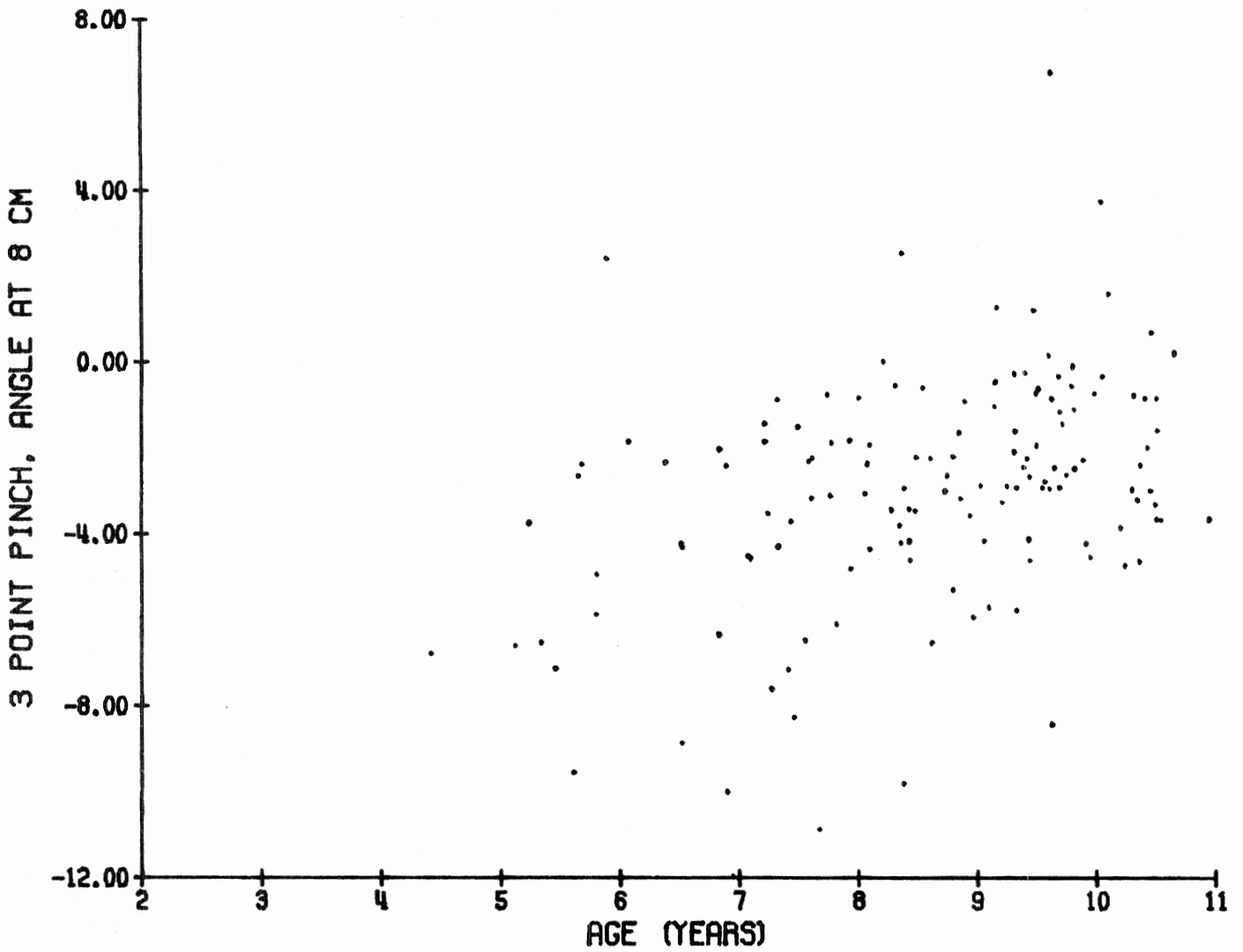
3 POINT PINCH, force location at 8 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	0.3	**	0.3	**	0.3	**	0.3
4.5-5.5	4	0.4	0.2	0.1	**	0.3	**	0.6
5.5-6.5	8	0.5	0.4	-0.2	**	0.5	**	0.8
6.5-7.5	20	0.7	0.3	0.1	**	0.7	**	1.2
7.5-8.5	29	0.6	0.3	-0.1	0.0	0.5	1.1	1.2
8.5-9.5	34	0.7	0.4	-0.0	0.0	0.5	1.3	1.8
9.5-10.5	43	0.6	0.3	-0.0	0.1	0.6	1.0	1.2



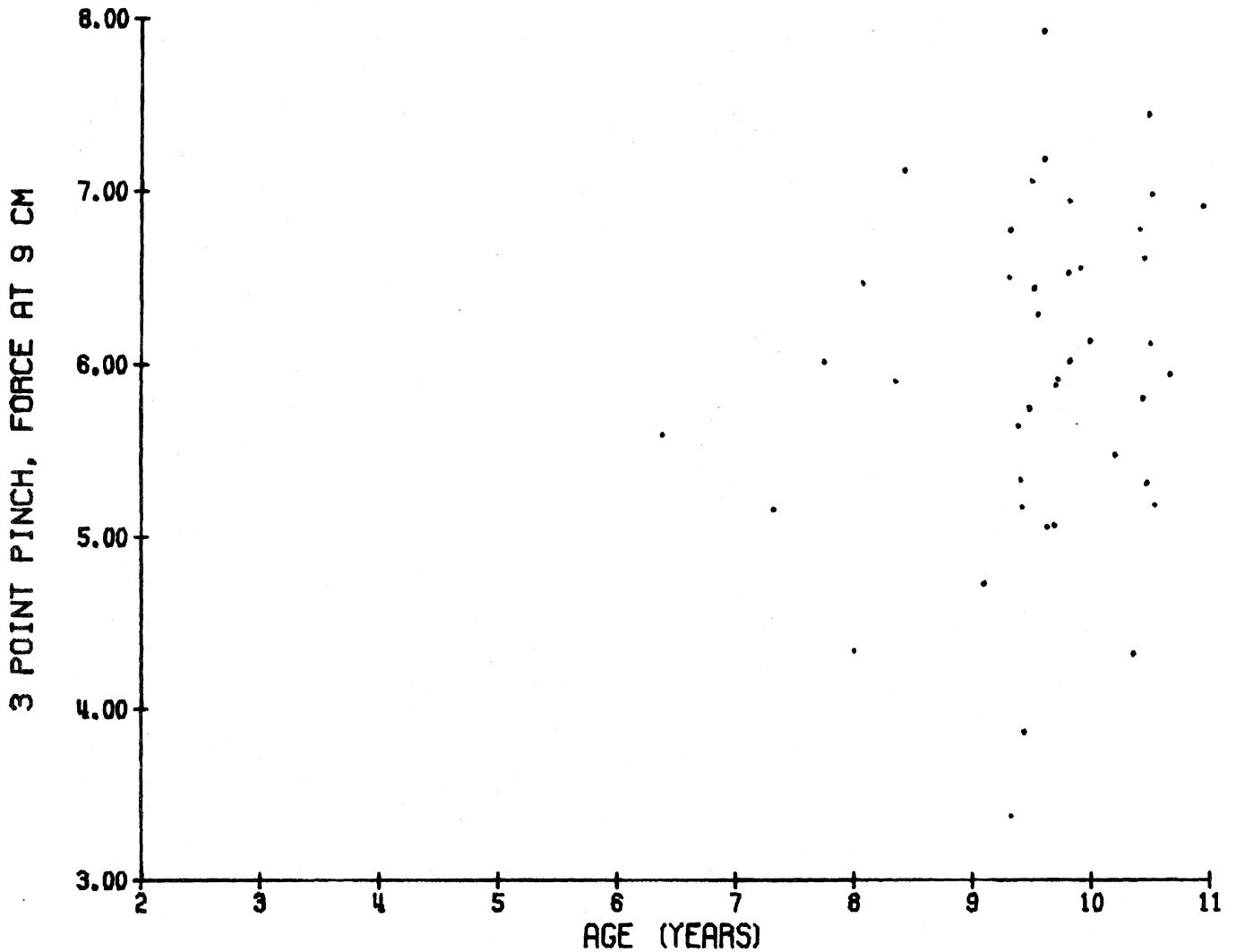
3 POINT PINCH, angle at 8 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	-6.8	**	-6.8	**	-6.8	**	-6.8
4.5-5.5	4	-6.0	1.5	-7.1	**	-6.6	**	-3.8
5.5-6.5	8	-3.4	3.5	-9.6	**	-2.7	**	2.4
6.5-7.5	20	-5.0	3.1	-12.0	**	-4.3	**	-0.9
7.5-8.5	29	-3.3	2.7	-10.9	-10.4	-3.2	-0.3	2.5
8.5-9.5	34	-2.6	1.9	-6.5	-6.1	-2.7	0.2	1.2
9.5-10.5	43	-1.8	2.4	-8.4	-4.7	-2.4	1.4	6.7



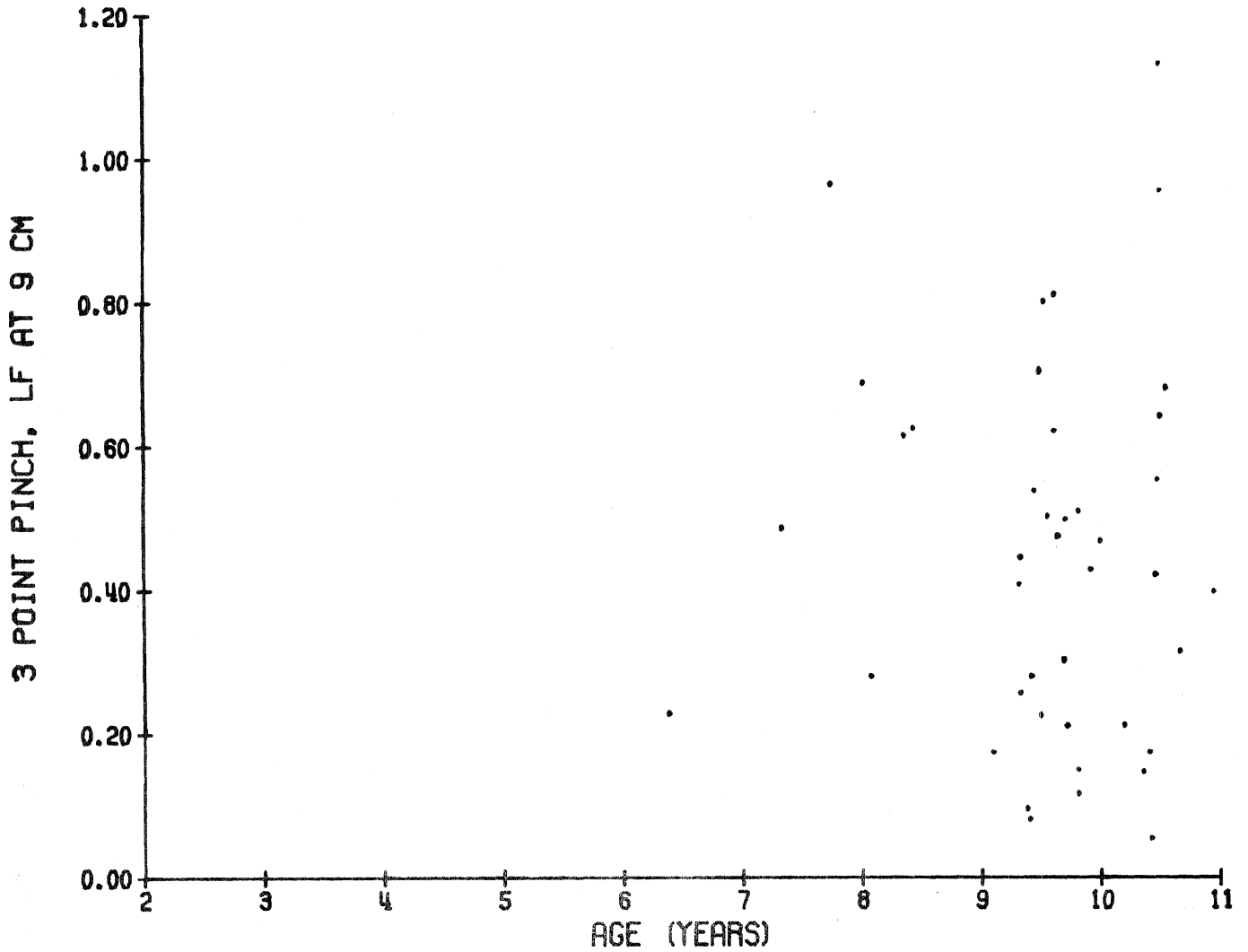
**3 POINT PINCH, force at 9 cm (Kgf)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	5.6	**	5.6	**	5.6	**	5.6
6.5-7.5	1	5.2	**	5.2	**	5.2	**	5.2
7.5-8.5	5	6.0	1.0	4.3	**	6.0	**	7.1
8.5-9.5	10	5.4	1.2	3.4	**	5.3	**	7.1
9.5-10.5	25	6.2	0.8	4.3	4.5	6.1	7.4	7.9



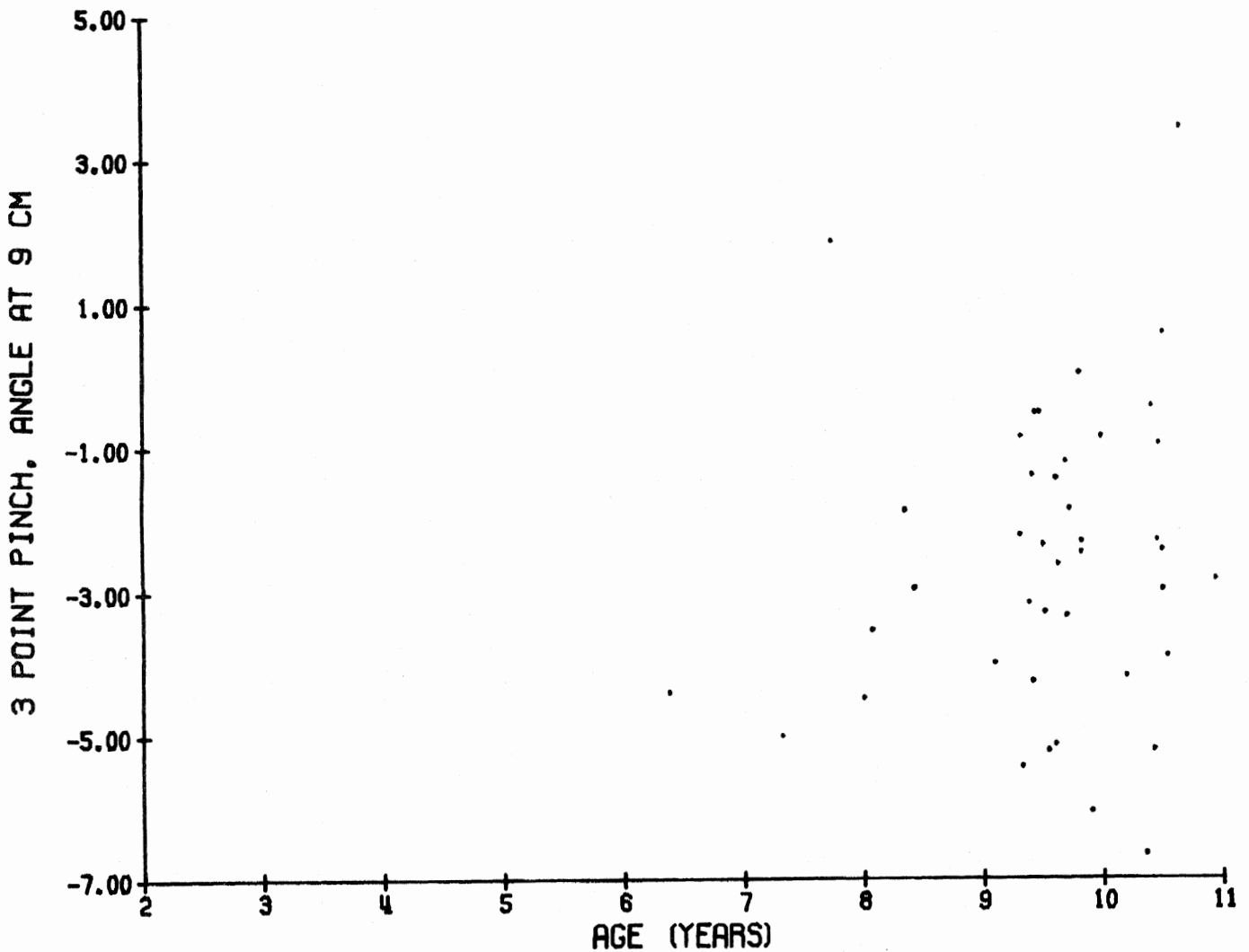
3 POINT PINCH, force location at 9 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	0.2	**	0.2	**	0.2	**	0.2
6.5-7.5	1	0.5	**	0.5	**	0.5	**	0.5
7.5-8.5	5	0.6	0.2	0.3	**	0.6	**	1.0
8.5-9.5	10	0.3	0.2	0.1	**	0.3	**	0.7
9.5-10.5	25	0.5	0.3	0.1	0.1	0.4	0.9	1.1



3 POINT PINCH, angle at 9 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	-4.4	**	-4.4	**	-4.4	**	-4.4
6.5-7.5	1	-5.0	**	-5.0	**	-5.0	**	-5.0
7.5-8.5	5	-2.2	2.5	-4.5	**	-3.2	**	1.9
8.5-9.5	10	-2.5	1.7	-5.4	**	-2.3	**	-0.5
9.5-10.5	25	-2.5	2.3	-6.7	-6.5	-2.5	0.5	3.5



GRIP: FIVE POINT PINCH

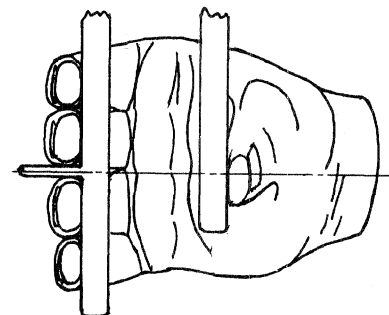
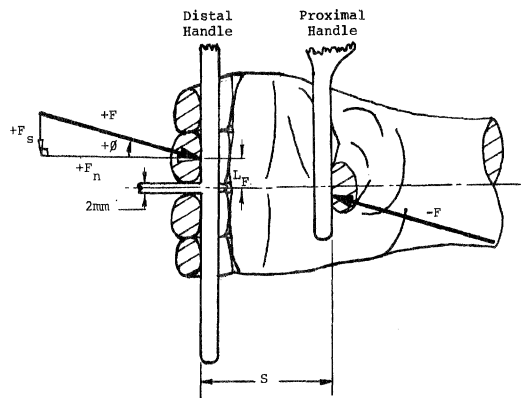
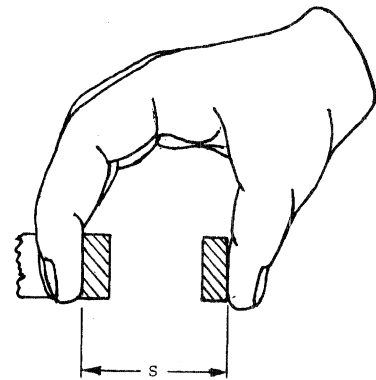
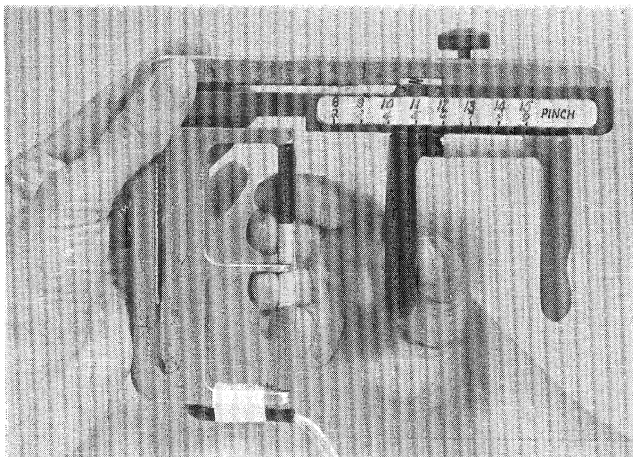
DESCRIPTION OF TEST: The anterior surface of all four finger tips (distal end of phalanges #2-#5) are pressed in opposition to the anterior surface of the thumb tip (distal end of phalanx #1).

TEST POSITION: Thumb and four fingers are flexed in the sagittal plane so that the thumb tip is opposite the second and third finger tips and the distal handle brace is between them.

ANTHROPOMETRIC MEASUREMENT: The length of the second finger (L) is measured from the tip to its palmar skinfold.

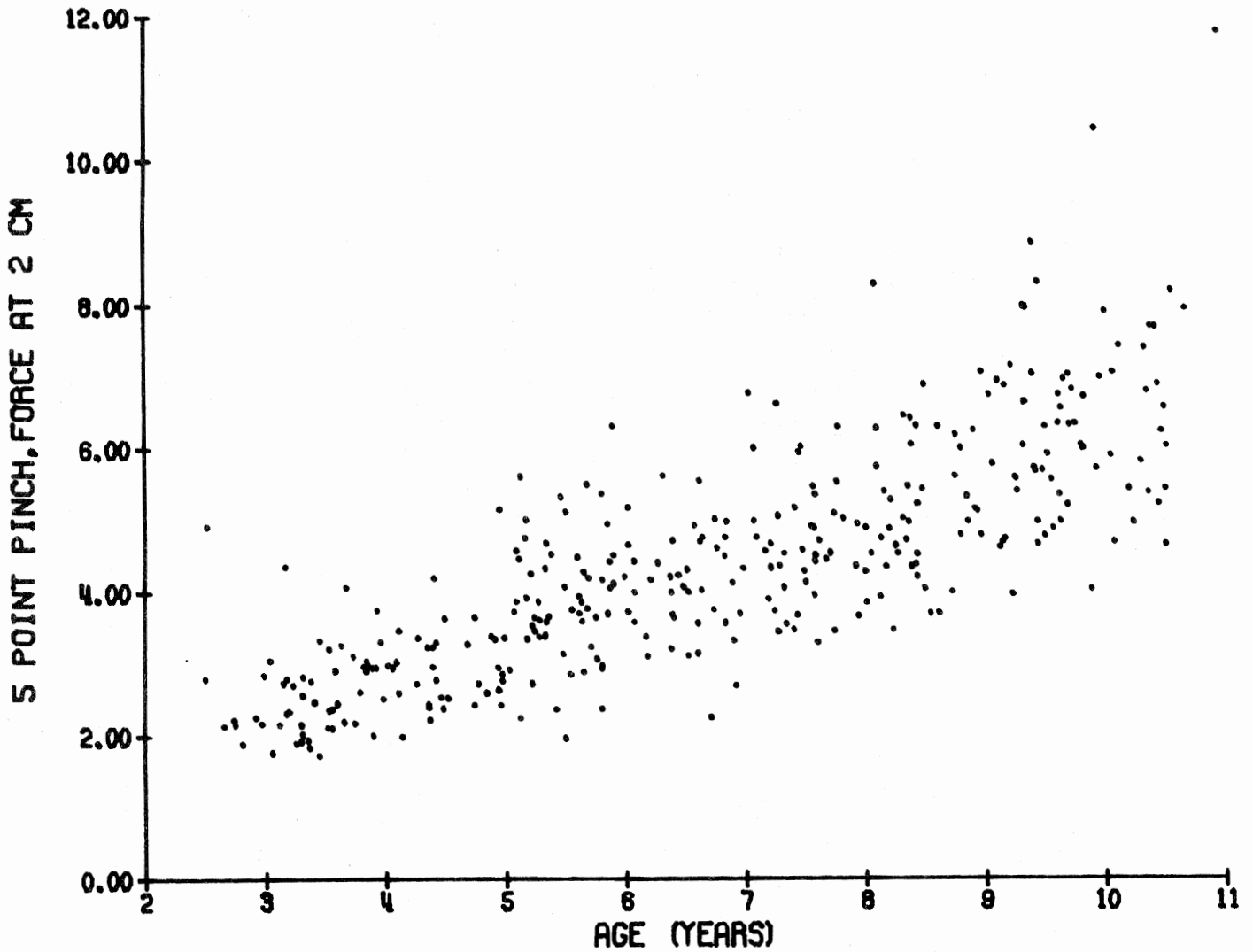
ADJUSTMENT OF EQUIPMENT: The pinch handle set is inserted into the transducer. The handle span (S) is then adjusted to the proper test position.

INSTRUCTIONS TO SUBJECT: The child brings the tips of the fingers together and pinches the two plates using his thumb and four fingers.



5 POINT PINCH, force at 2 cm (Kgf)  
(Males and Females)

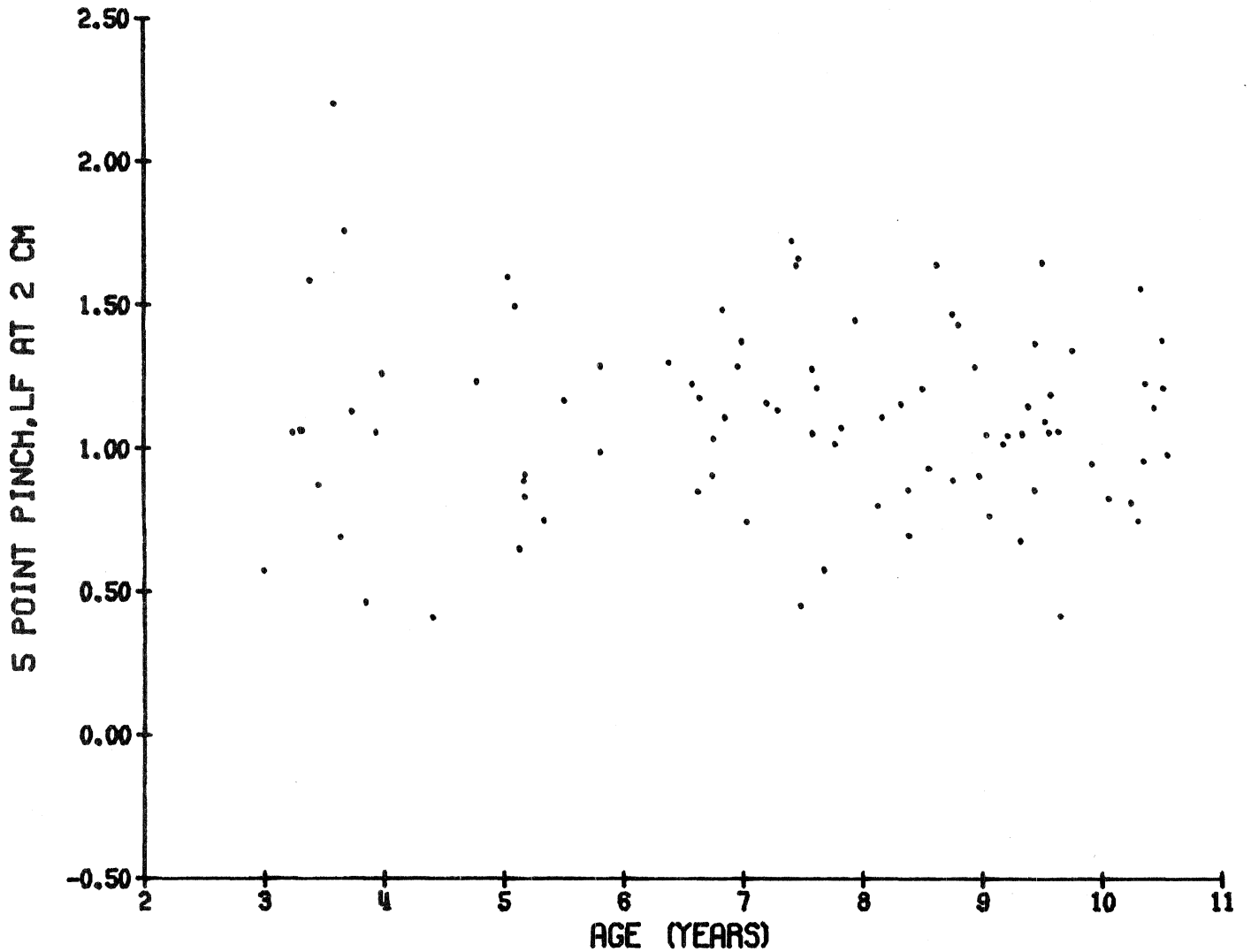
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	2.5	0.7	1.7	1.7	2.3	3.8	4.9
3.5-4.5	45	2.9	0.5	2.0	2.0	2.9	3.7	4.2
4.5-5.5	44	3.6	0.9	2.3	2.4	3.5	5.1	5.6
5.5-6.5	49	4.0	0.8	2.0	2.6	4.0	5.5	6.3
6.5-7.5	46	4.4	1.0	2.3	2.8	4.4	6.0	6.8
7.5-8.5	52	5.0	0.9	3.3	3.5	4.8	6.5	8.3
8.5-9.5	42	5.8	1.2	3.7	3.8	5.7	8.0	8.9
9.5-10.5	45	6.5	1.4	4.1	4.7	6.3	8.2	11.8





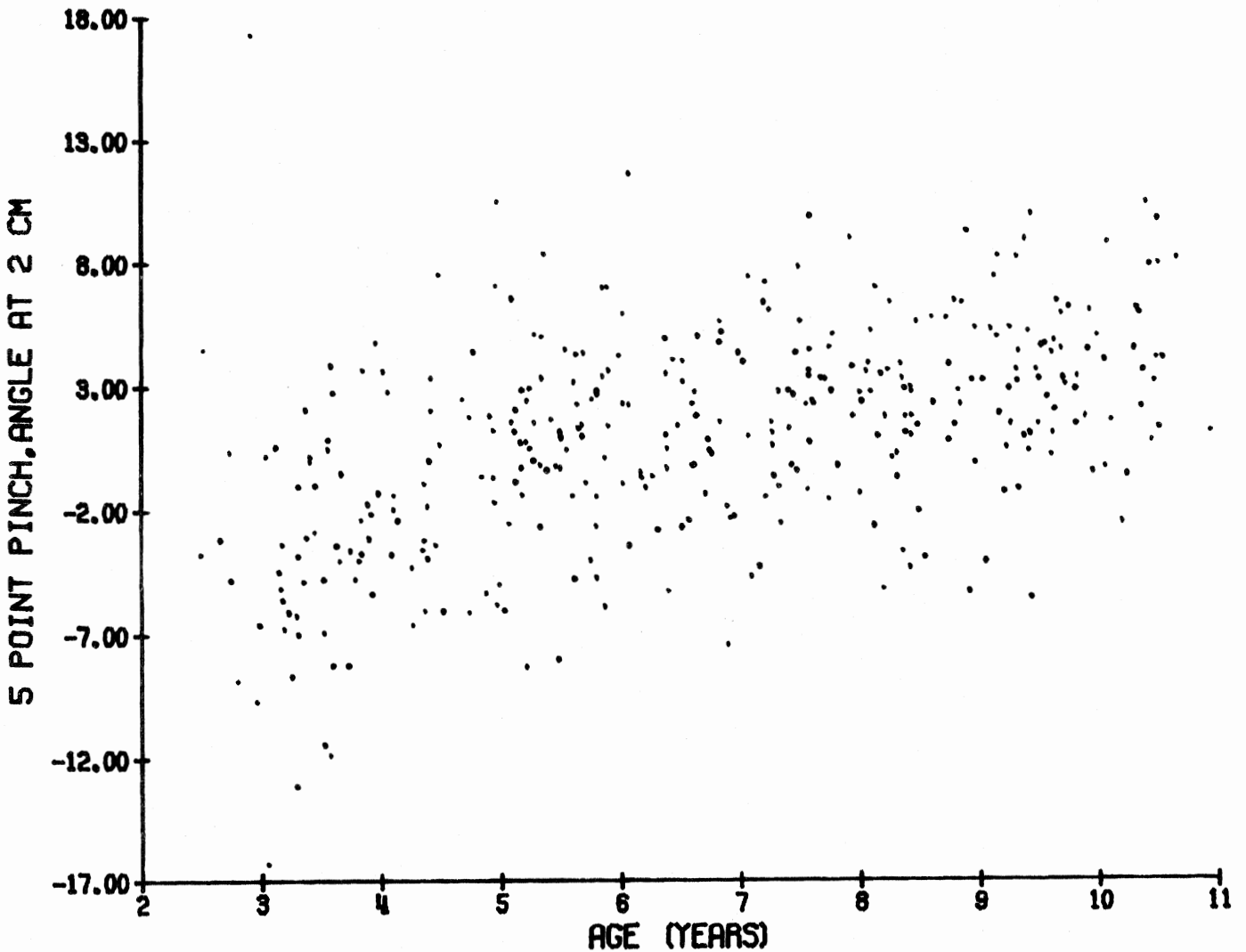
5 POINT PINCH, force location at 2 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.1	0.5	0.2	0.3	1.1	2.0	2.2
3.5-4.5	45	1.2	0.5	-0.3	-0.0	1.2	1.9	2.2
4.5-5.5	44	1.1	0.4	0.1	0.5	1.0	1.6	1.8
5.5-6.5	49	1.0	0.4	0.1	0.4	1.0	1.6	2.3
6.5-7.5	46	1.1	0.4	0.3	0.4	1.1	1.7	2.0
7.5-8.5	52	1.0	0.3	0.3	0.5	0.9	1.4	1.6
8.5-9.5	42	1.0	0.3	0.5	0.6	1.0	1.6	1.6
9.5-10.5	45	1.0	0.3	0.4	0.4	1.0	1.4	1.5



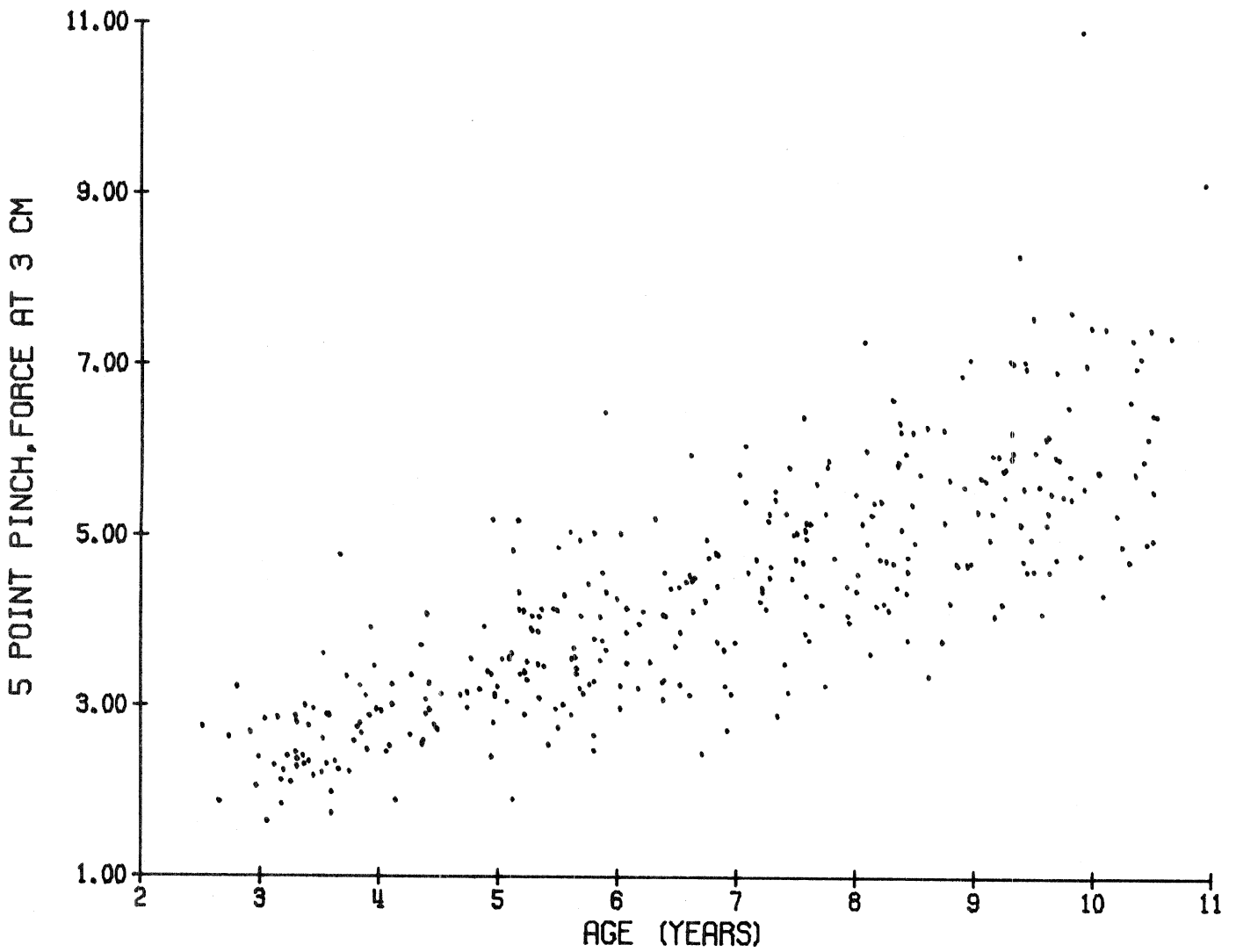
5 POINT PINCH, angle at 2 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	-3.6	5.8	-16.3	-14.5	-4.1	3.2	17.3
3.5-4.5	45	-2.2	4.1	-11.8	-10.6	-2.7	3.8	7.6
4.5-5.5	44	0.4	4.2	-8.2	-7.6	0.8	7.0	10.6
5.5-6.5	49	1.2	3.5	-5.8	-5.0	1.2	6.6	11.7
6.5-7.5	46	1.5	3.4	-7.3	-4.5	1.2	7.0	7.9
7.5-8.5	52	2.4	3.0	-5.1	-3.8	2.8	6.7	10.0
8.5-9.5	42	3.1	3.8	-5.5	-5.1	3.3	9.0	10.1
9.5-10.5	45	4.0	2.9	-2.4	-0.5	4.0	8.8	10.6



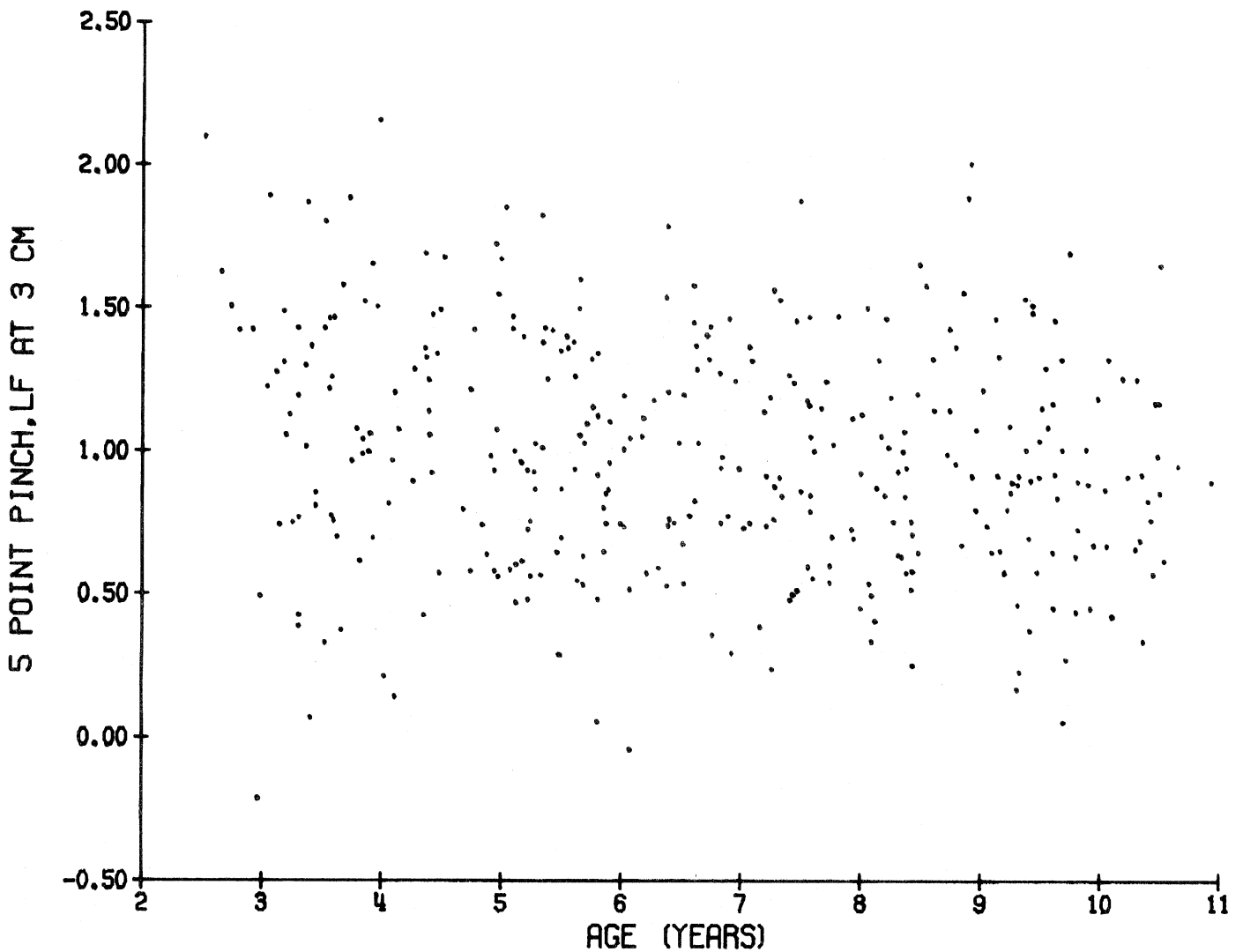
5 POINT PINCH, force at 3 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	2.5	0.4	1.6	1.7	2.4	3.0	3.2
3.5-4.5	45	2.9	0.6	1.7	1.9	2.8	3.9	4.8
4.5-5.5	44	3.5	0.7	1.9	2.4	3.5	4.7	5.2
5.5-6.5	49	3.8	0.8	2.5	2.7	3.7	5.0	6.4
6.5-7.5	46	4.4	0.9	2.4	2.8	4.5	5.8	6.0
7.5-8.5	52	5.0	0.9	3.2	3.7	4.9	6.3	7.3
8.5-9.5	42	5.6	1.1	3.4	3.8	5.6	7.1	8.3
9.5-10.5	45	6.1	1.3	4.1	4.4	5.8	7.6	10.9



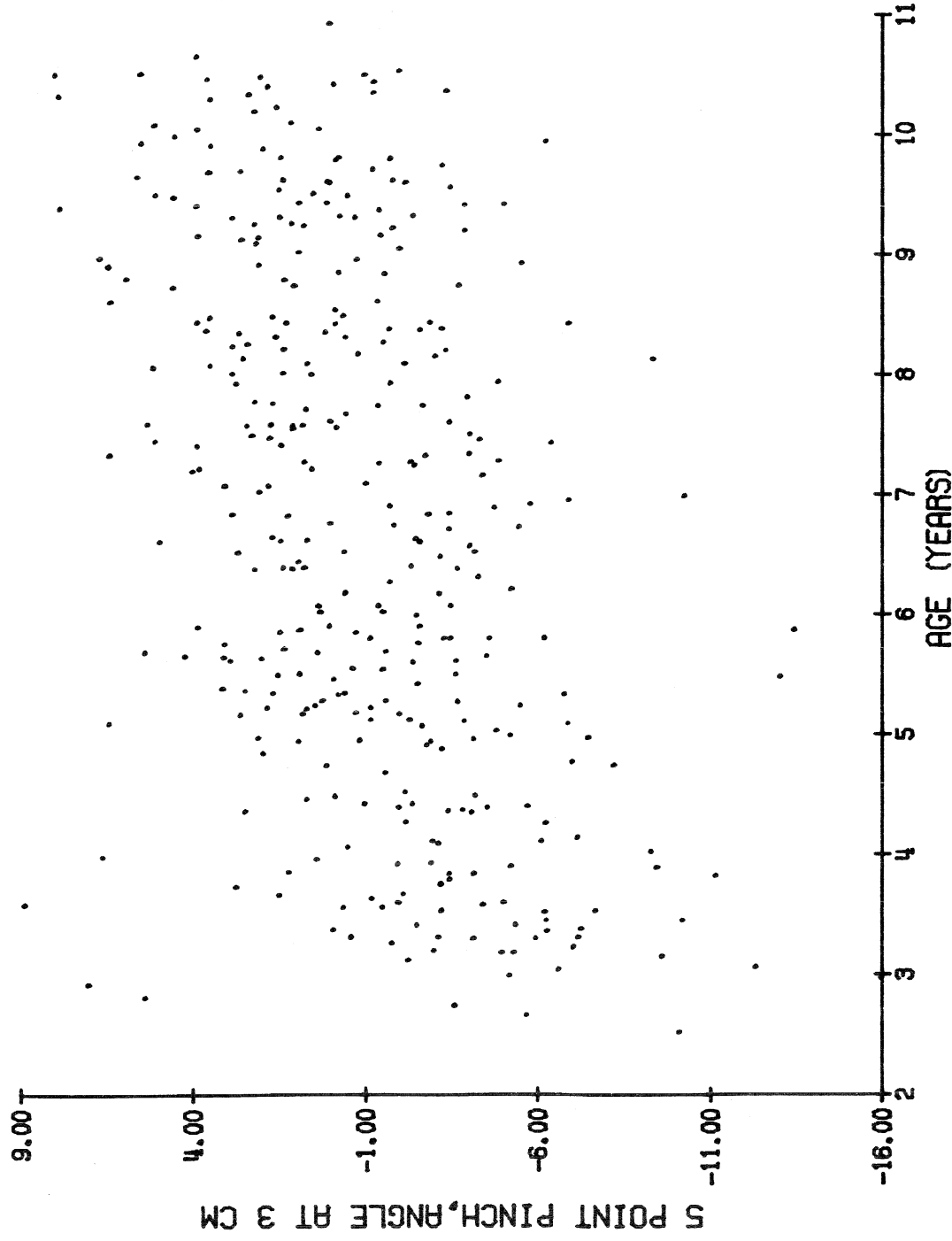
5 POINT PINCH, force location at 3 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	1.1	0.5	-0.2	-0.1	1.2	1.9	2.1
3.5-4.5	45	1.1	0.5	0.1	0.2	1.1	1.8	2.2
4.5-5.5	44	1.0	0.4	0.3	0.5	1.0	1.7	1.9
5.5-6.5	49	0.9	0.4	-0.0	0.2	1.0	1.5	1.8
6.5-7.5	46	1.0	0.4	0.2	0.3	0.9	1.6	1.9
7.5-8.5	52	0.9	0.3	0.3	0.4	0.8	1.5	1.7
8.5-9.5	42	1.0	0.4	0.2	0.2	0.9	1.6	2.0
9.5-10.5	45	0.9	0.4	0.1	0.3	0.9	1.4	1.7



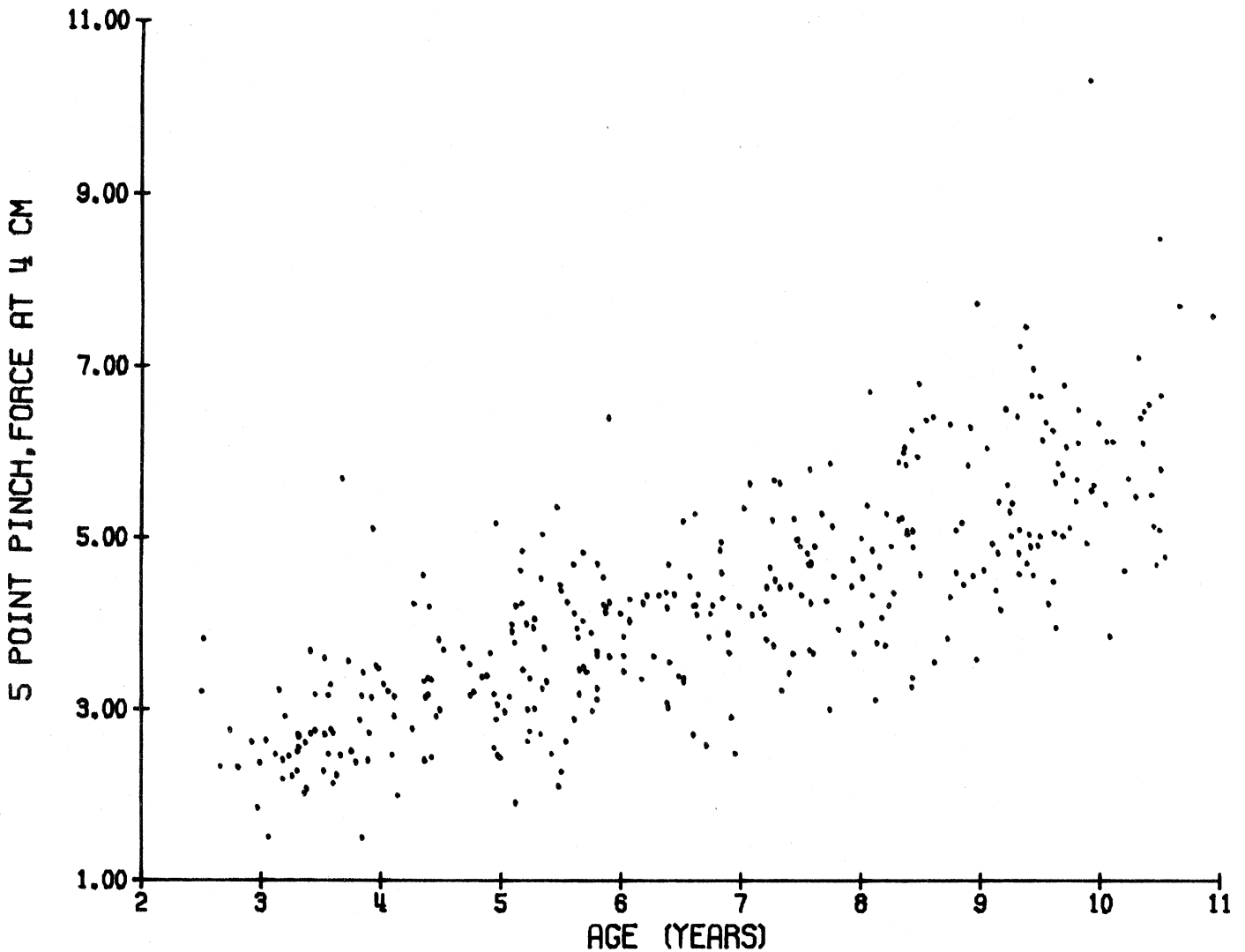
5 POINT PINCH, angle at 3 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	28	-5.0	4.7	-16.0	-14.5	-5.4	3.2	7.0
3.5-4.5	45	-2.7	3.8	-11.1	-9.4	-3.2	2.7	8.9
4.5-5.5	44	-1.8	3.6	-13.0	-8.0	-1.6	2.6	6.4
5.5-6.5	49	-1.1	3.2	-13.4	-5.8	-1.3	3.5	5.4
6.5-7.5	46	-0.9	3.7	-10.3	-6.8	-1.4	4.6	6.4
7.5-8.5	52	-0.0	3.0	-9.4	-5.7	0.5	3.7	5.3
8.5-9.5	42	0.9	3.3	-5.6	-4.9	0.9	6.4	7.8
9.5-10.5	45	1.3	3.0	-6.3	-3.5	1.4	5.5	7.9



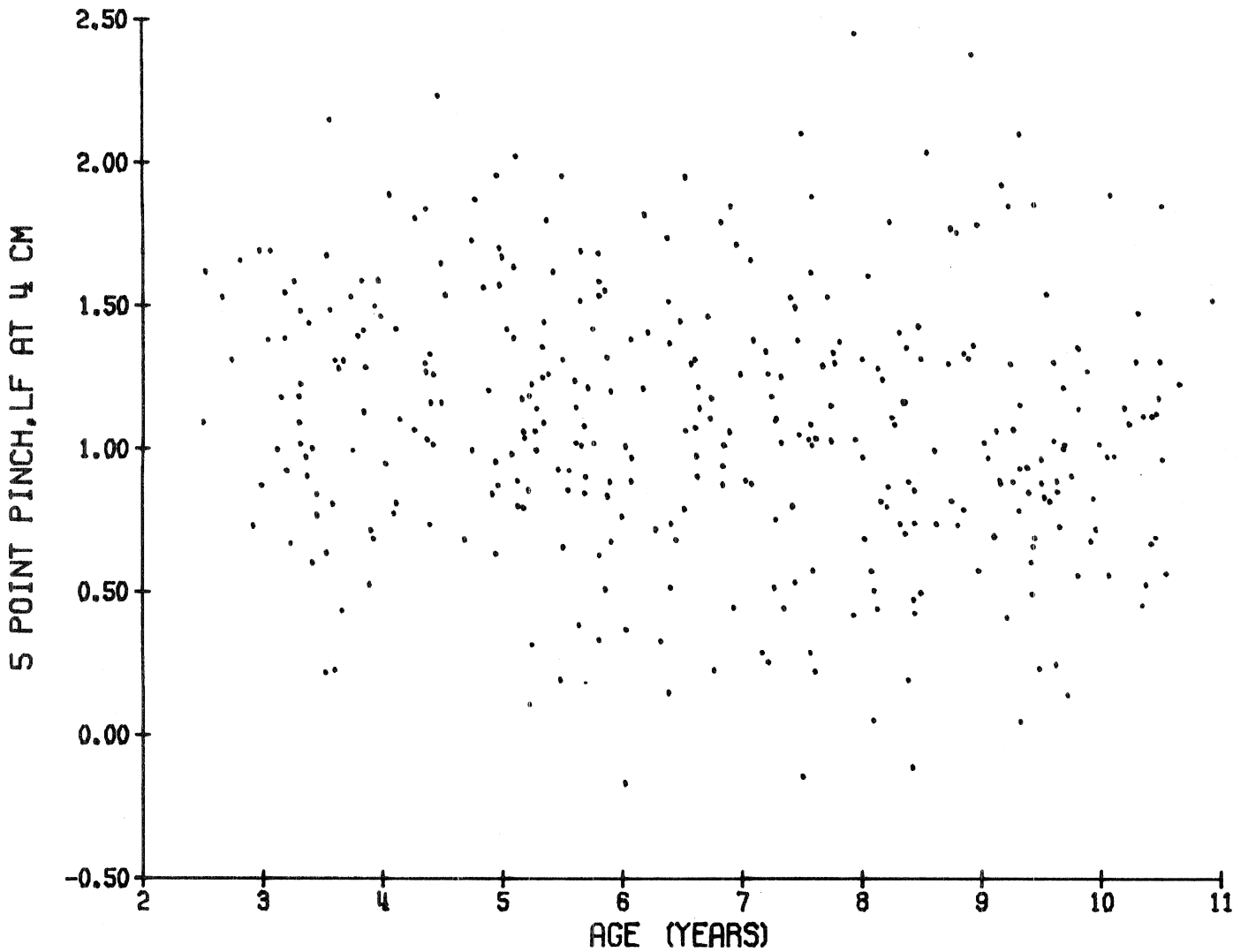
5 POINT PINCH, force at 4 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	2.6	0.5	1.5	1.7	2.5	3.5	3.8
3.5-4.5	45	3.1	0.8	1.5	2.0	3.1	4.5	5.7
4.5-5.5	44	3.5	0.8	1.9	2.2	3.4	5.0	5.4
5.5-6.5	49	3.9	0.7	2.3	2.7	3.9	4.7	6.4
6.5-7.5	46	4.3	0.8	2.5	2.6	4.2	5.6	5.7
7.5-8.5	52	4.8	0.9	3.0	3.2	4.7	6.2	6.8
8.5-9.5	42	5.4	1.0	3.6	3.6	5.1	7.2	7.8
9.5-10.5	45	5.9	1.2	3.9	4.0	5.7	7.7	10.3



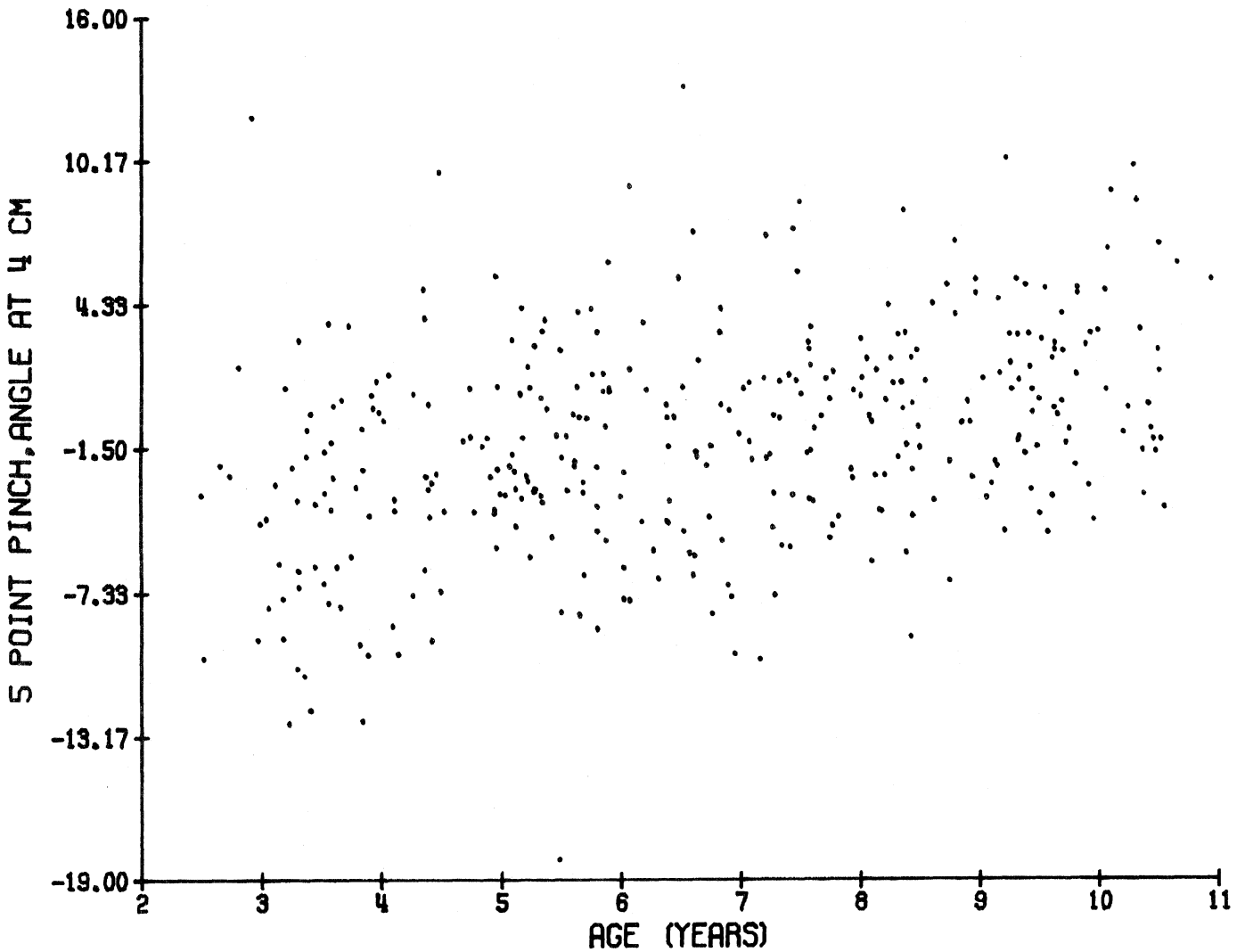
5 POINT PINCH, force location at 4 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	1.2	0.3	0.6	0.6	1.1	1.7	1.7
3.5-4.5	45	1.2	0.5	0.2	0.3	1.3	1.9	2.2
4.5-5.5	44	1.2	0.5	0.1	0.2	1.2	1.9	2.0
5.5-6.5	49	1.0	0.5	-0.2	0.2	1.0	1.7	1.8
6.5-7.5	46	1.1	0.4	0.2	0.3	1.1	1.8	2.1
7.5-8.5	52	1.0	0.5	-0.1	-0.0	1.0	1.7	2.4
8.5-9.5	42	1.1	0.5	0.0	0.2	0.9	2.0	2.4
9.5-10.5	45	1.0	0.4	0.1	0.3	1.0	1.5	1.9



5 POINT PINCH, angle at 4 cm (Degrees)  
(Males and Females)

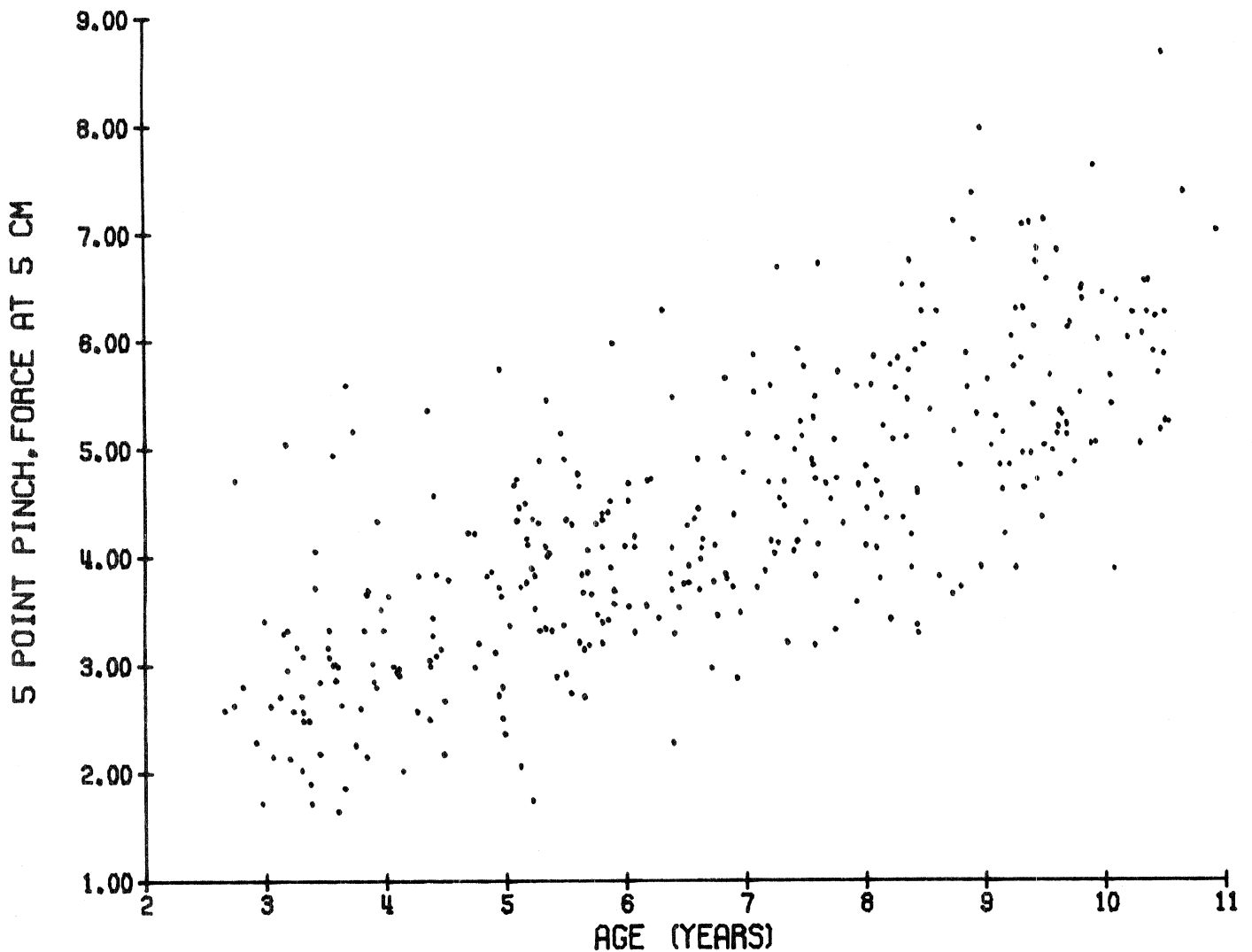
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	-4.5	5.2	-12.6	-12.4	-4.4	2.4	11.9
3.5-4.5	45	-2.9	4.6	-12.5	-9.8	-3.0	3.8	9.7
4.5-5.5	44	-1.7	3.8	-18.2	-5.8	-2.3	3.7	5.5
5.5-6.5	49	-1.6	4.0	-8.8	-8.1	-1.9	4.9	9.2
6.5-7.5	46	-1.1	5.1	-10.0	-9.3	-1.6	7.4	13.3
7.5-8.5	52	-0.4	3.2	-9.1	-5.8	-0.1	3.4	8.2
8.5-9.5	42	0.8	3.6	-6.8	-4.7	0.6	5.4	10.4
9.5-10.5	45	1.7	3.7	-4.8	-4.2	1.7	8.2	10.1





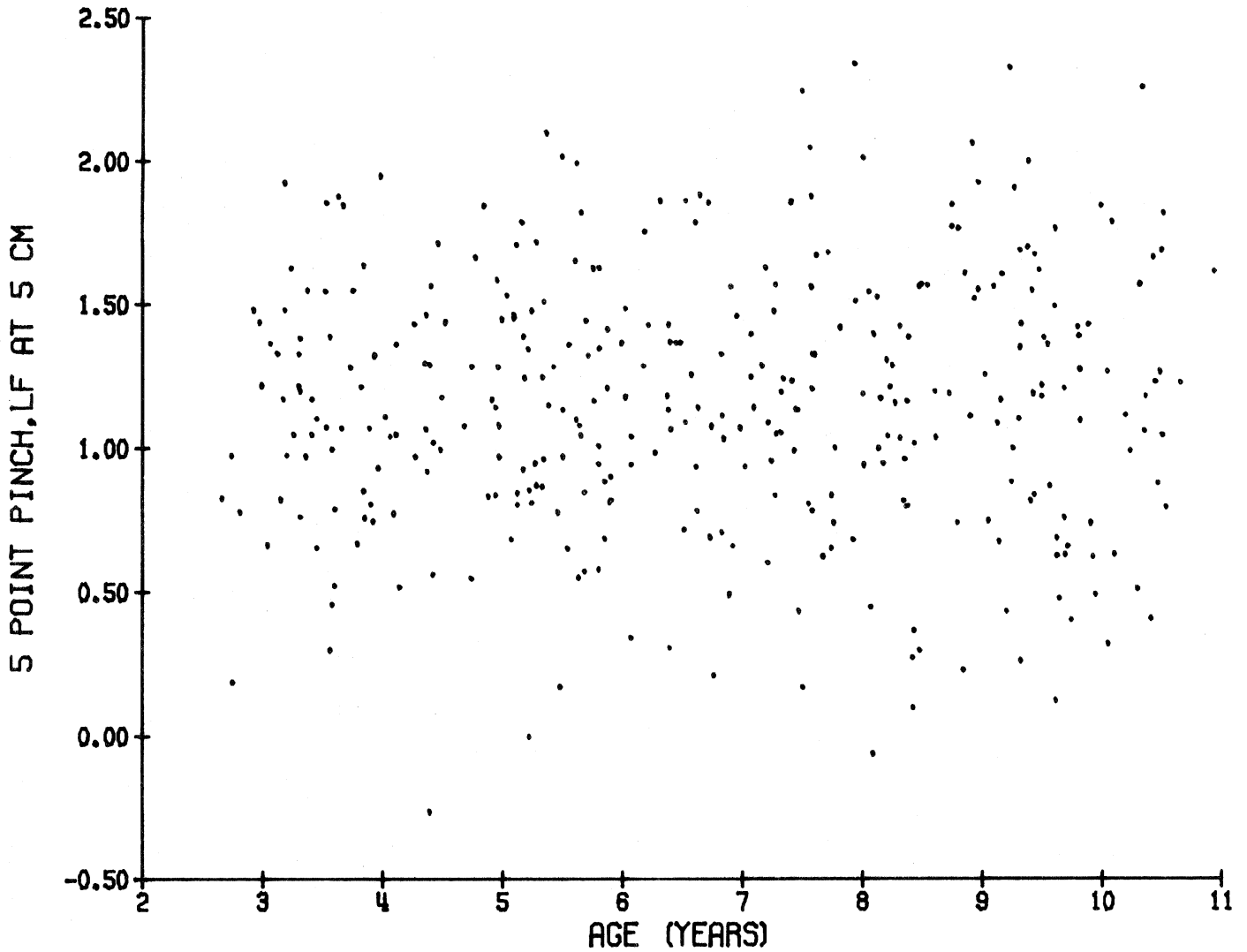
5 POINT PINCH, force at 5 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	2.8	0.8	1.7	1.7	2.6	4.4	5.0
3.5-4.5	45	3.2	0.9	1.6	1.9	3.0	5.1	5.6
4.5-5.5	44	3.8	0.9	1.7	2.1	3.8	5.1	5.7
5.5-6.5	49	3.9	0.8	2.3	2.7	3.8	5.1	6.3
6.5-7.5	46	4.4	0.8	2.9	3.0	4.2	5.8	6.7
7.5-8.5	52	4.9	0.9	3.2	3.3	4.7	6.5	6.7
8.5-9.5	42	5.5	1.1	3.6	3.7	5.3	7.1	8.0
9.5-10.5	45	5.9	0.9	3.9	4.8	5.9	7.3	8.6



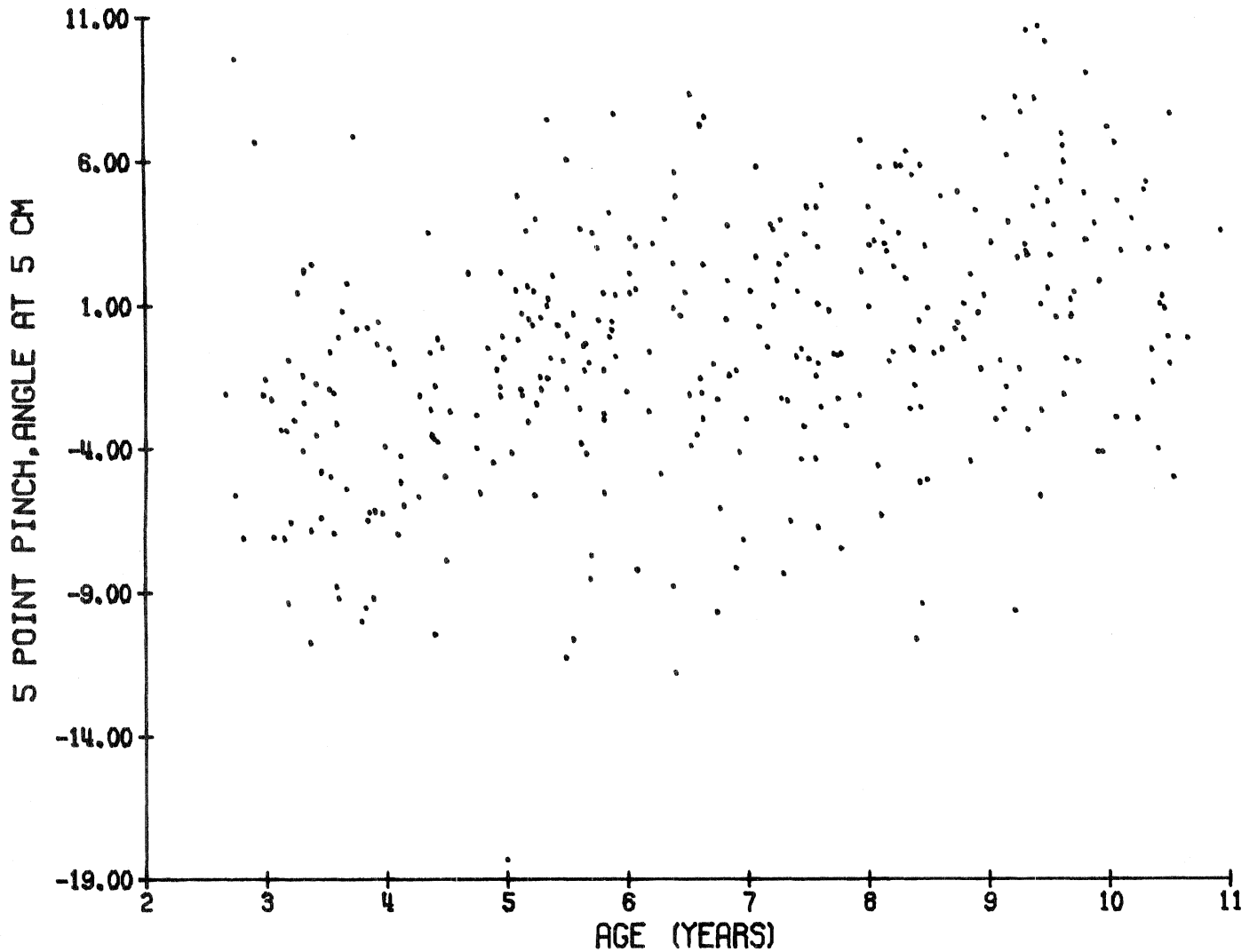
5 POINT PINCH, force location at 5 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	1.1	0.5	-1.0	-0.5	1.1	1.6	1.9
3.5-4.5	45	1.1	0.5	-0.3	0.3	1.1	1.9	2.0
4.5-5.5	44	1.2	0.4	0.0	0.2	1.2	1.8	2.1
5.5-6.5	49	1.2	0.4	0.3	0.4	1.2	1.8	2.0
6.5-7.5	46	1.2	0.4	0.2	0.5	1.1	1.9	2.3
7.5-8.5	52	1.1	0.5	-0.1	0.1	1.0	1.9	2.3
8.5-9.5	42	1.3	0.5	0.2	0.3	1.3	2.0	2.3
9.5-10.5	45	1.1	0.5	0.1	0.3	1.1	1.8	2.3



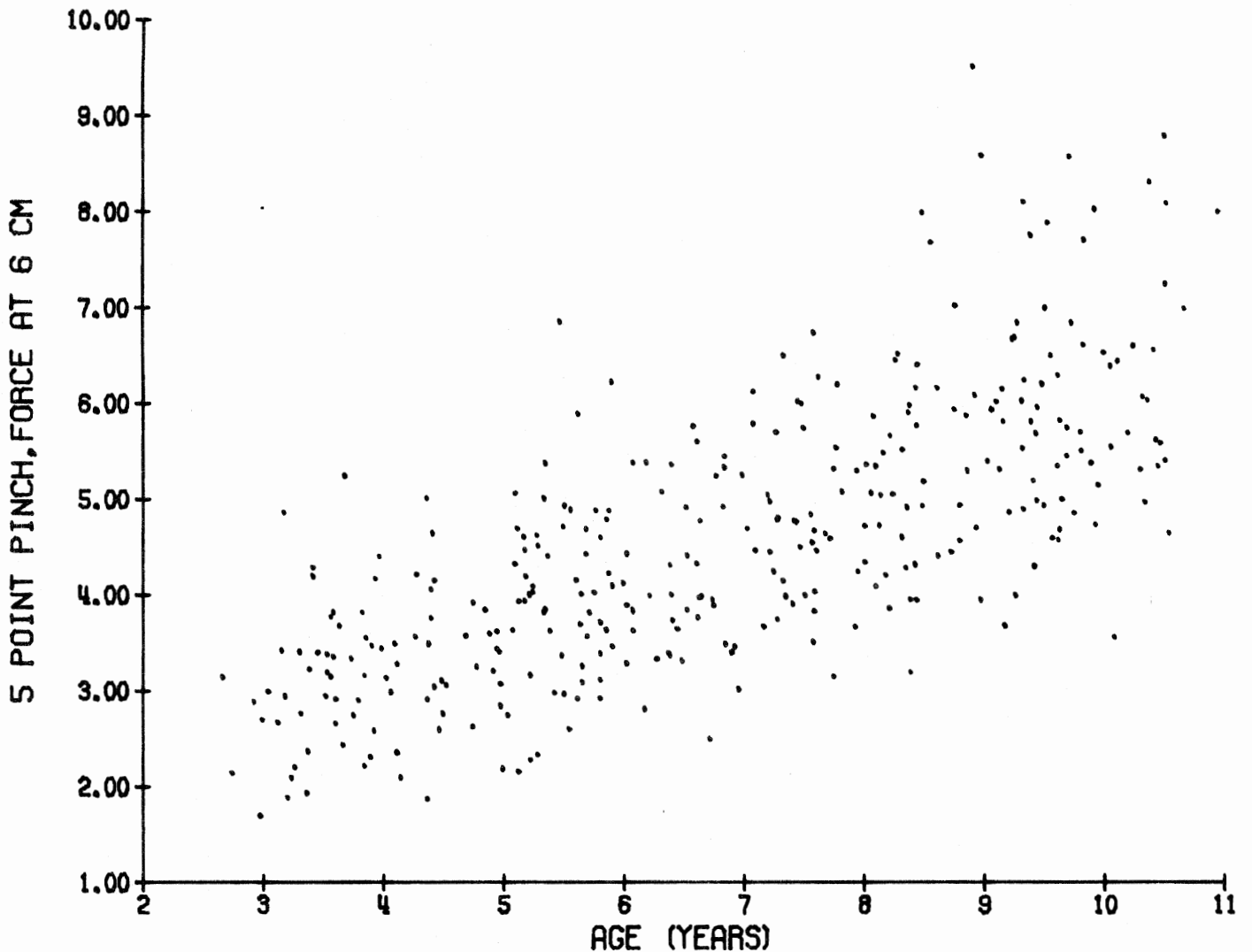
5 POINT PINCH, angle at 5 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	29	-2.7	4.5	-10.7	-10.1	-3.2	4.8	9.5
3.5-4.5	45	-3.6	3.8	-10.5	-9.9	-3.7	1.5	6.8
4.5-5.5	44	-1.2	4.1	-18.3	-10.2	-0.9	3.9	7.4
5.5-6.5	49	-0.6	4.4	-11.8	-9.8	0.0	5.2	7.6
6.5-7.5	46	-0.5	4.3	-9.7	-8.3	-0.9	6.7	8.2
7.5-8.5	52	0.1	4.2	-10.7	-8.3	-0.6	5.7	6.6
8.5-9.5	42	1.9	4.5	-9.7	-5.6	1.5	9.8	10.5
9.5-10.5	45	1.8	3.5	-5.1	-4.2	1.5	7.0	8.9



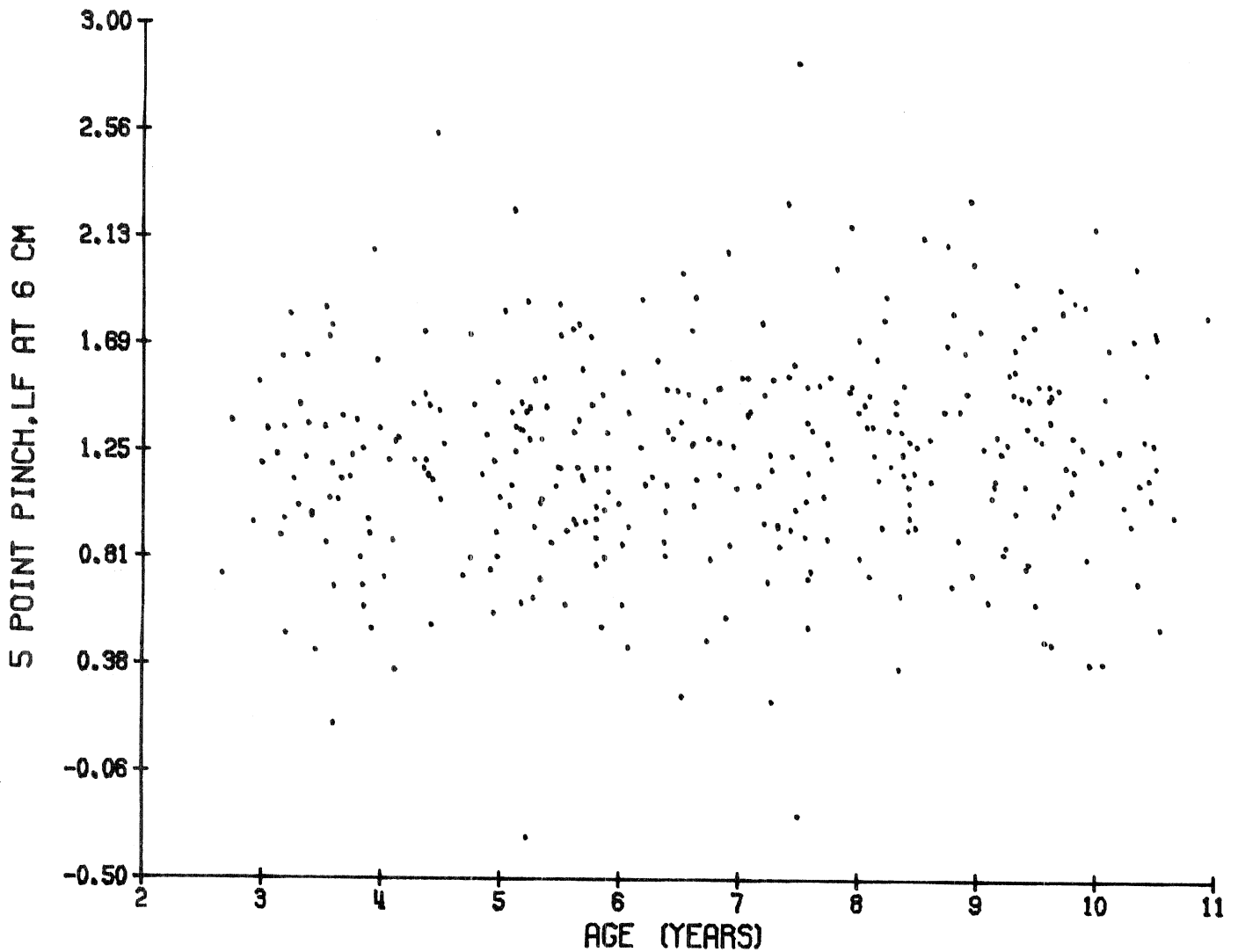
5 POINT PINCH, force at 6 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	22	2.9	0.8	1.7	1.7	2.9	4.3	4.9
3.5-4.5	45	3.3	0.7	1.9	2.1	3.2	4.6	5.2
4.5-5.5	43	3.8	0.9	2.2	2.2	3.7	5.1	6.9
5.5-6.5	49	4.0	0.8	2.6	2.9	3.9	5.4	6.2
6.5-7.5	46	4.6	0.9	2.5	3.1	4.5	6.0	6.5
7.5-8.5	52	5.0	1.0	3.2	3.4	4.9	6.5	8.0
8.5-9.5	42	5.9	1.3	3.7	4.0	5.8	8.1	9.5
9.5-10.5	45	6.1	1.2	3.6	4.6	5.7	8.3	8.8



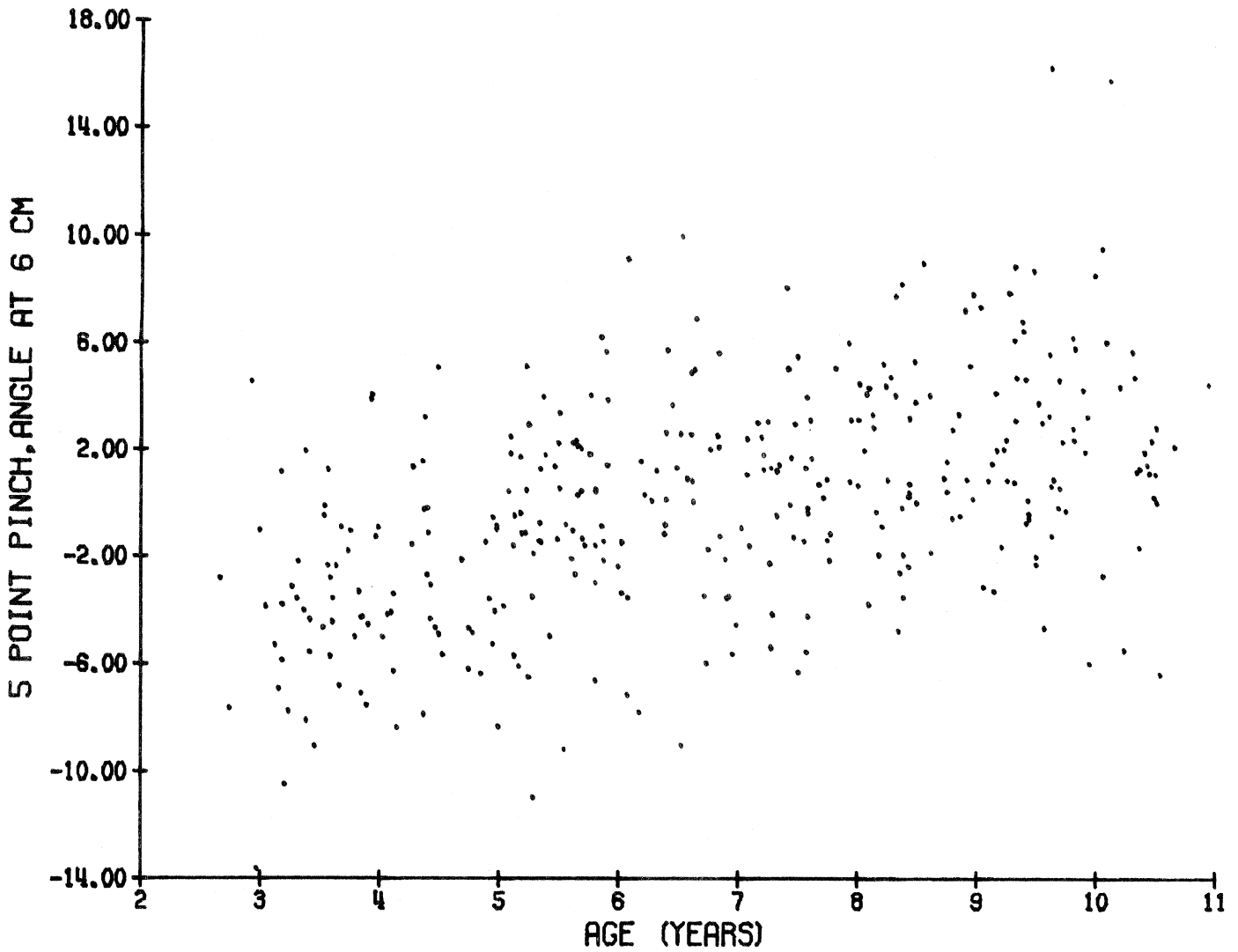
5 POINT PINCH, force location at 6 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	22	1.2	0.4	0.4	0.4	1.2	1.6	1.8
3.5-4.5	45	1.2	0.4	0.1	0.4	1.2	1.8	2.5
4.5-5.5	43	1.2	0.4	-0.3	0.6	1.2	1.8	2.2
5.5-6.5	49	1.2	0.3	0.4	0.5	1.1	1.7	1.9
6.5-7.5	46	1.3	0.5	0.2	0.3	1.3	2.0	2.8
7.5-8.5	52	1.2	0.4	-0.2	0.5	1.2	1.8	2.2
8.5-9.5	42	1.4	0.4	0.6	0.6	1.3	2.1	2.3
9.5-10.5	45	1.3	0.4	0.4	0.4	1.3	1.9	2.2



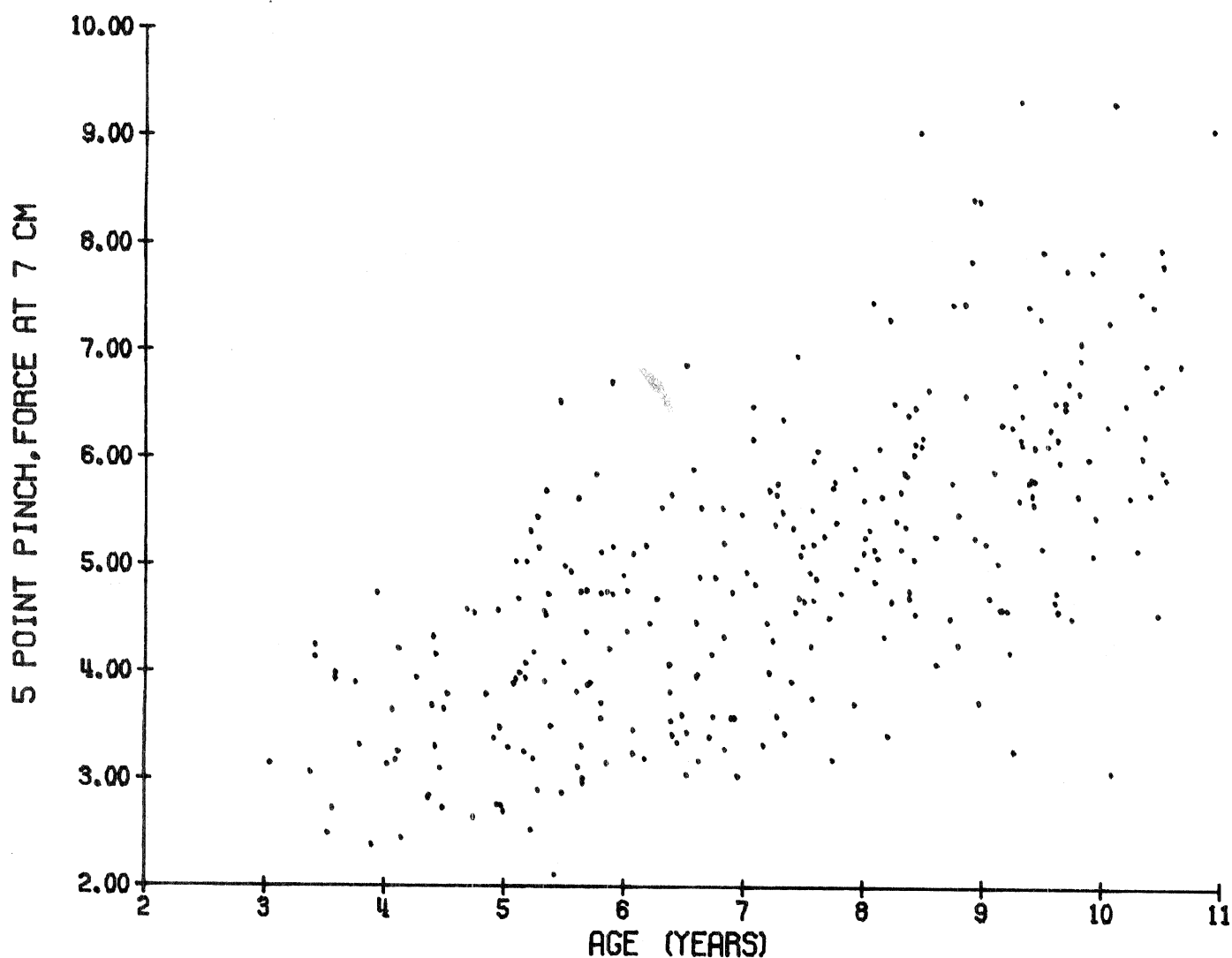
5 POINT PINCH, angle at 6 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	22	-4.6	4.2	-13.6	-13.3	-4.3	1.9	4.6
3.5-4.5	45	-2.6	3.2	-8.4	-7.8	-3.2	3.7	5.1
4.5-5.5	43	-1.9	3.5	-10.9	-8.0	-1.4	2.9	5.2
5.5-6.5	49	0.0	3.5	-9.2	-7.5	0.1	5.7	9.2
6.5-7.5	46	0.7	3.9	-9.0	-5.8	1.3	6.6	10.0
7.5-8.5	52	1.1	3.3	-6.3	-5.0	0.8	5.7	8.3
8.5-9.5	42	2.6	3.6	-3.2	-3.0	1.6	8.7	9.0
9.5-10.5	45	2.6	4.5	-6.3	-5.8	2.3	9.4	16.3



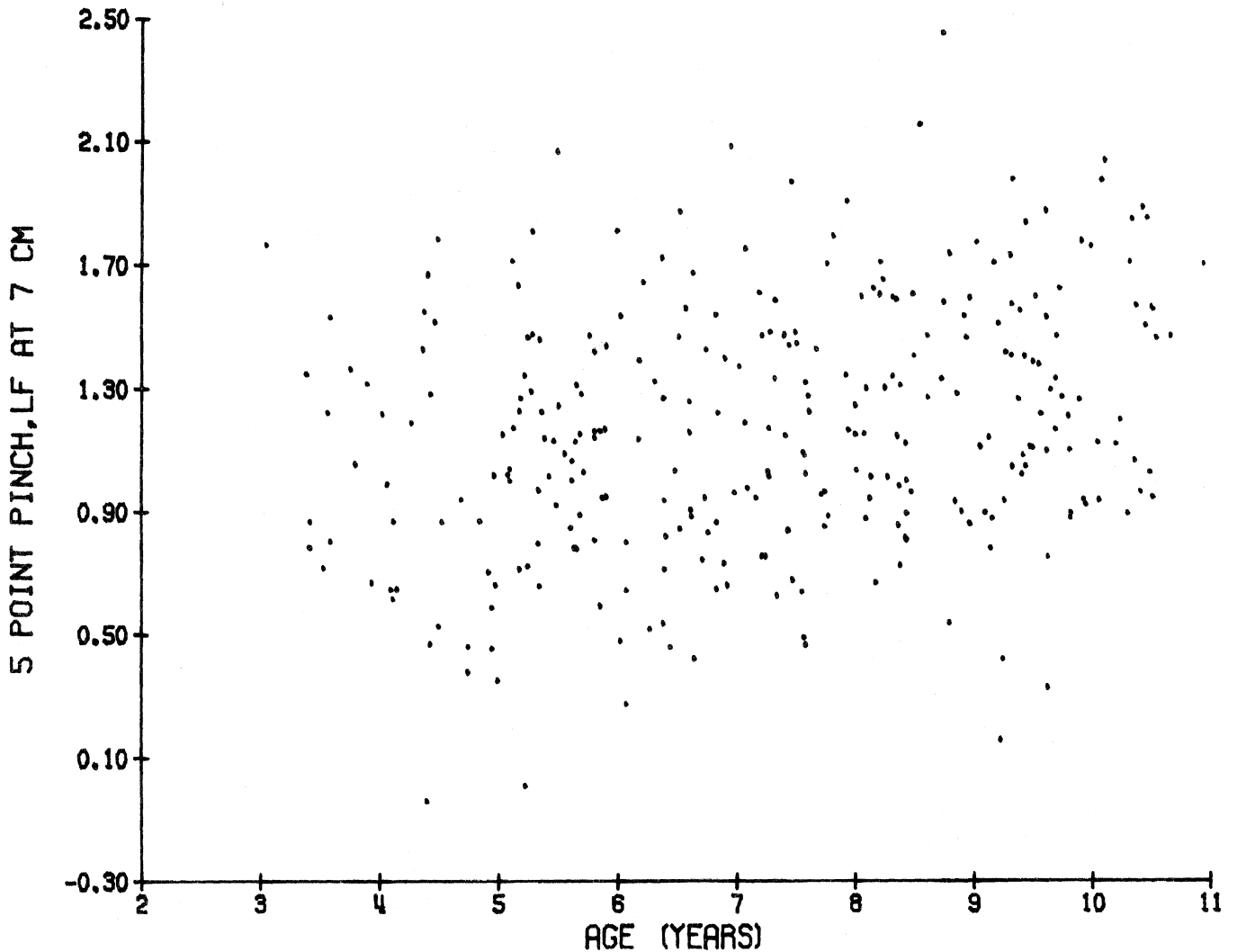
5 POINT PINCH, force at 7 cm (Kfg)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	4	3.6	0.6	3.1	**	3.1	**	4.2
3.5-4.5	24	3.4	0.7	2.4	2.4	3.3	4.3	4.7
4.5-5.5	38	4.0	1.0	2.1	2.5	3.9	5.5	6.5
5.5-6.5	43	4.3	0.9	3.0	3.0	4.3	5.6	6.7
6.5-7.5	46	4.7	1.1	3.0	3.1	4.7	6.4	6.9
7.5-8.5	52	5.4	1.0	3.2	3.6	5.3	6.8	9.0
8.5-9.5	42	5.9	1.4	3.3	3.8	5.8	8.3	9.3
9.5-10.5	45	6.4	1.2	3.1	4.5	6.4	7.9	9.3



5 POINT PINCH, force location at 7 cm  
(Males and Females)

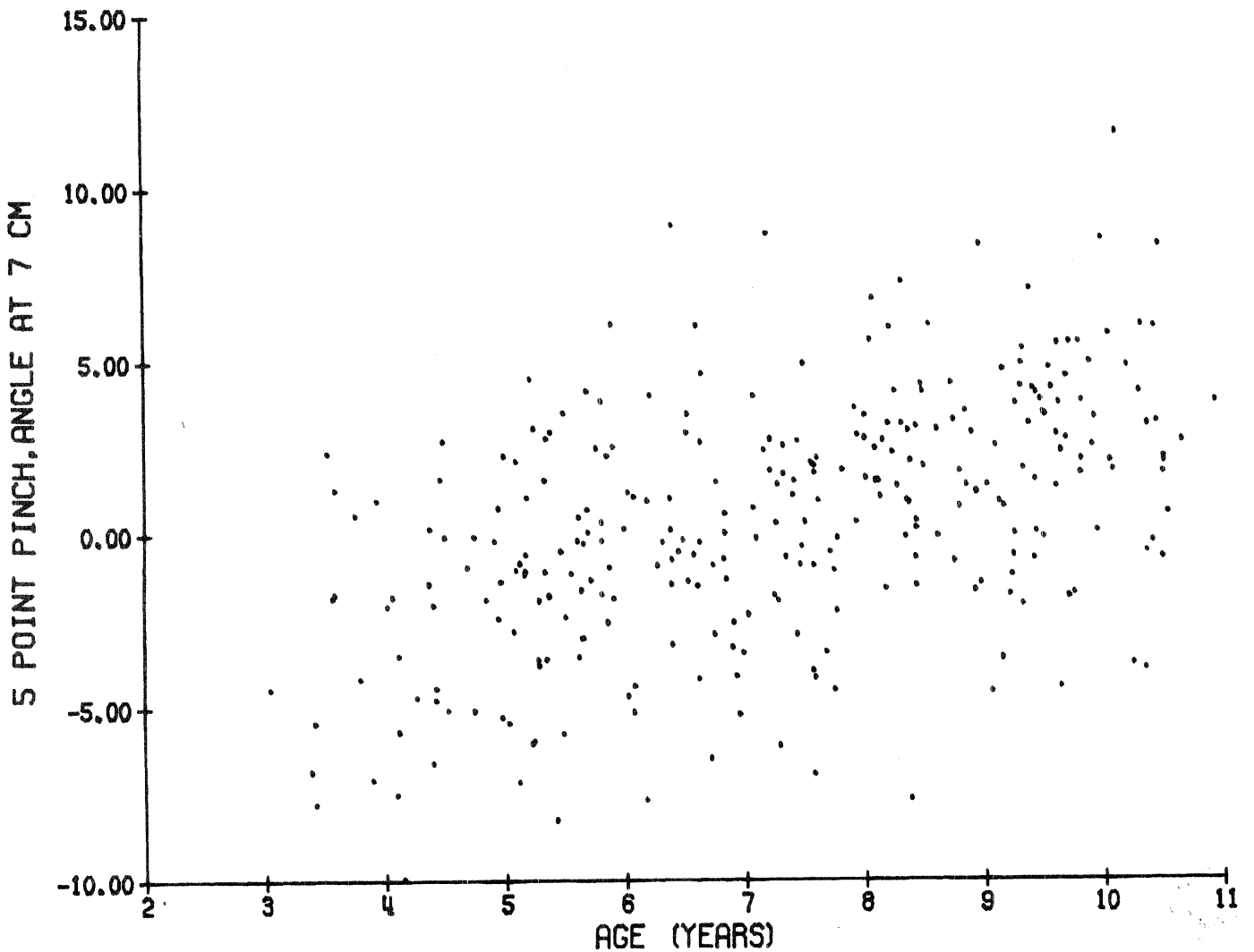
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	4	1.2	0.5	0.8	**	0.9	**	1.8
3.5-4.5	24	1.0	0.5	-0.0	0.1	1.1	1.6	1.8
4.5-5.5	38	1.0	0.4	0.0	0.3	1.0	1.7	2.1
5.5-6.5	43	1.1	0.4	0.3	0.5	1.1	1.6	1.8
6.5-7.5	46	1.2	0.4	0.4	0.6	1.2	1.8	2.1
7.5-8.5	52	1.2	0.3	0.5	0.6	1.2	1.7	1.9
8.5-9.5	42	1.3	0.5	0.2	0.4	1.3	2.0	2.5
9.5-10.5	45	1.3	0.4	0.3	0.8	1.3	1.9	2.1





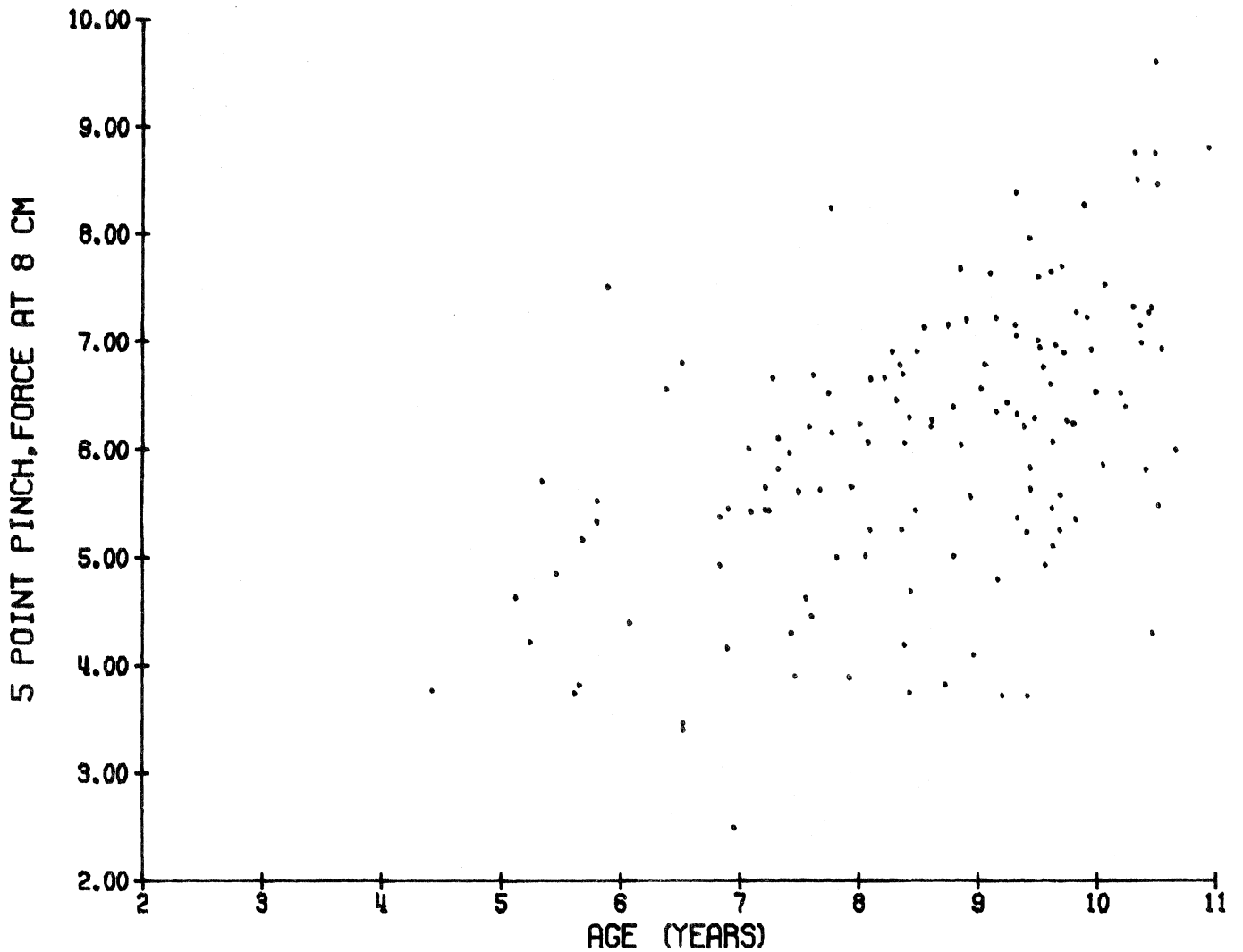
5 POINT PINCH, angle at 7 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	4	-6.1	1.5	-7.8	**	-6.8	**	-4.5
3.5-4.5	24	-2.5	3.4	-9.9	-9.4	-2.0	2.2	2.7
4.5-5.5	38	-1.6	3.2	-8.3	-7.3	-1.1	3.1	4.5
5.5-6.5	43	-0.3	3.0	-7.7	-5.1	-0.3	4.1	8.9
6.5-7.5	46	0.1	3.2	-6.5	-5.8	-0.3	4.8	8.7
7.5-8.5	52	1.1	3.1	-7.7	-5.5	1.5	5.7	7.3
8.5-9.5	42	1.8	2.8	-4.5	-3.4	1.5	6.0	8.3
9.5-10.5	45	2.8	3.2	-4.4	-3.9	2.8	7.7	11.5



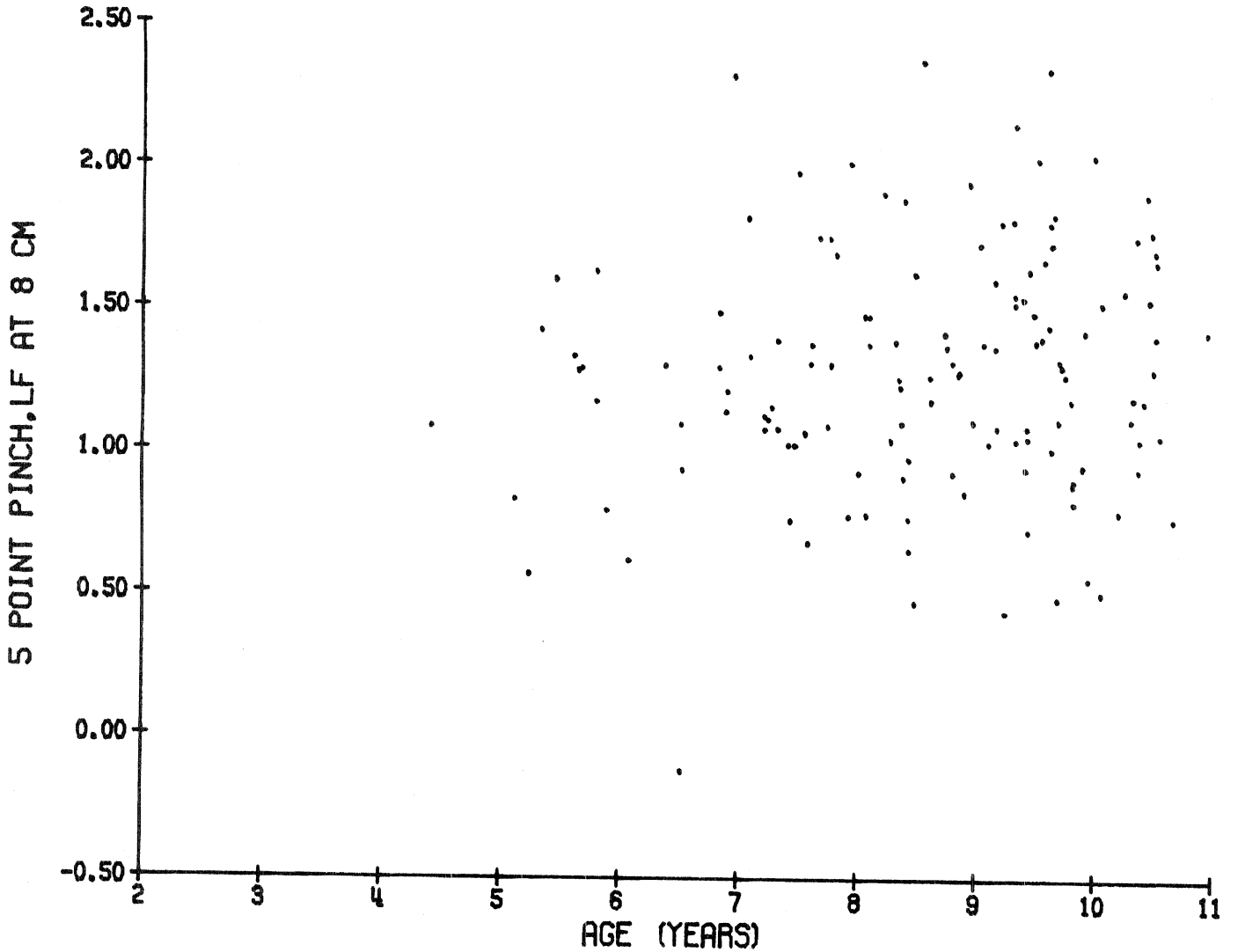
5 POINT PINCH, force at 8 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	3.8	**	3.8	**	3.8	**	3.8
4.5-5.5	4	4.9	0.6	4.2	**	4.6	**	5.7
5.5-6.5	8	5.3	1.3	3.7	**	5.2	**	7.5
6.5-7.5	20	5.1	1.1	2.5	**	5.5	**	6.8
7.5-8.5	29	5.8	1.1	3.8	3.8	6.1	6.9	8.3
8.5-9.5	34	6.3	1.2	3.7	3.7	6.3	7.8	8.4
9.5-10.5	42	6.8	1.2	4.3	5.0	6.9	8.8	9.6



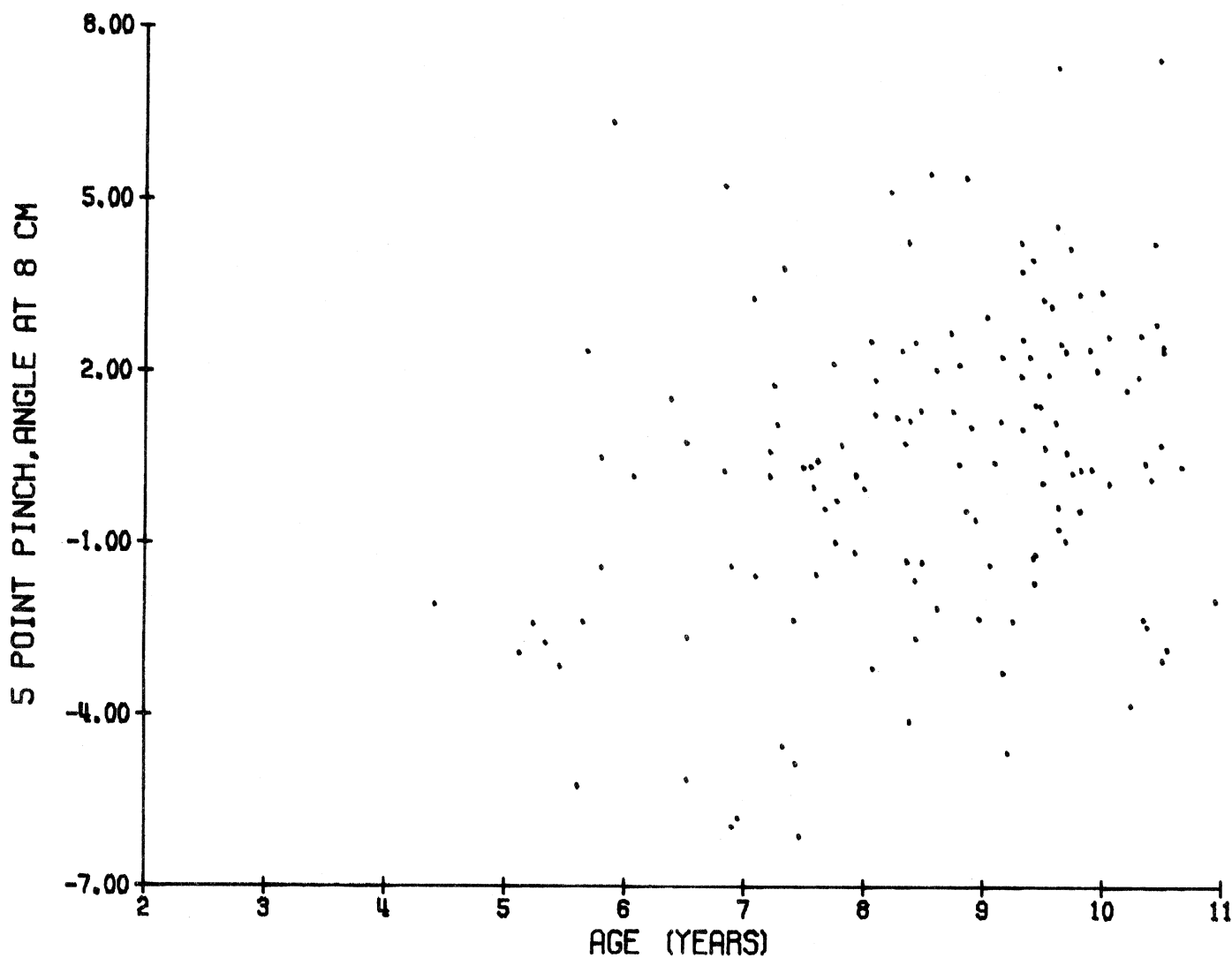
5 POINT PINCH, force location at 8 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	1.1	**	1.1	**	1.1	**	1.1
4.5-5.5	4	1.1	0.5	0.6	**	0.8	**	1.6
5.5-6.5	8	1.2	0.3	0.6	**	1.3	**	1.6
6.5-7.5	20	1.2	0.5	-0.1	**	1.1	**	2.3
7.5-8.5	29	1.2	0.4	0.5	0.5	1.2	1.9	2.0
8.5-9.5	34	1.3	0.4	0.4	0.6	1.4	2.0	2.4
9.5-10.5	42	1.3	0.4	0.5	0.5	1.3	2.0	2.3



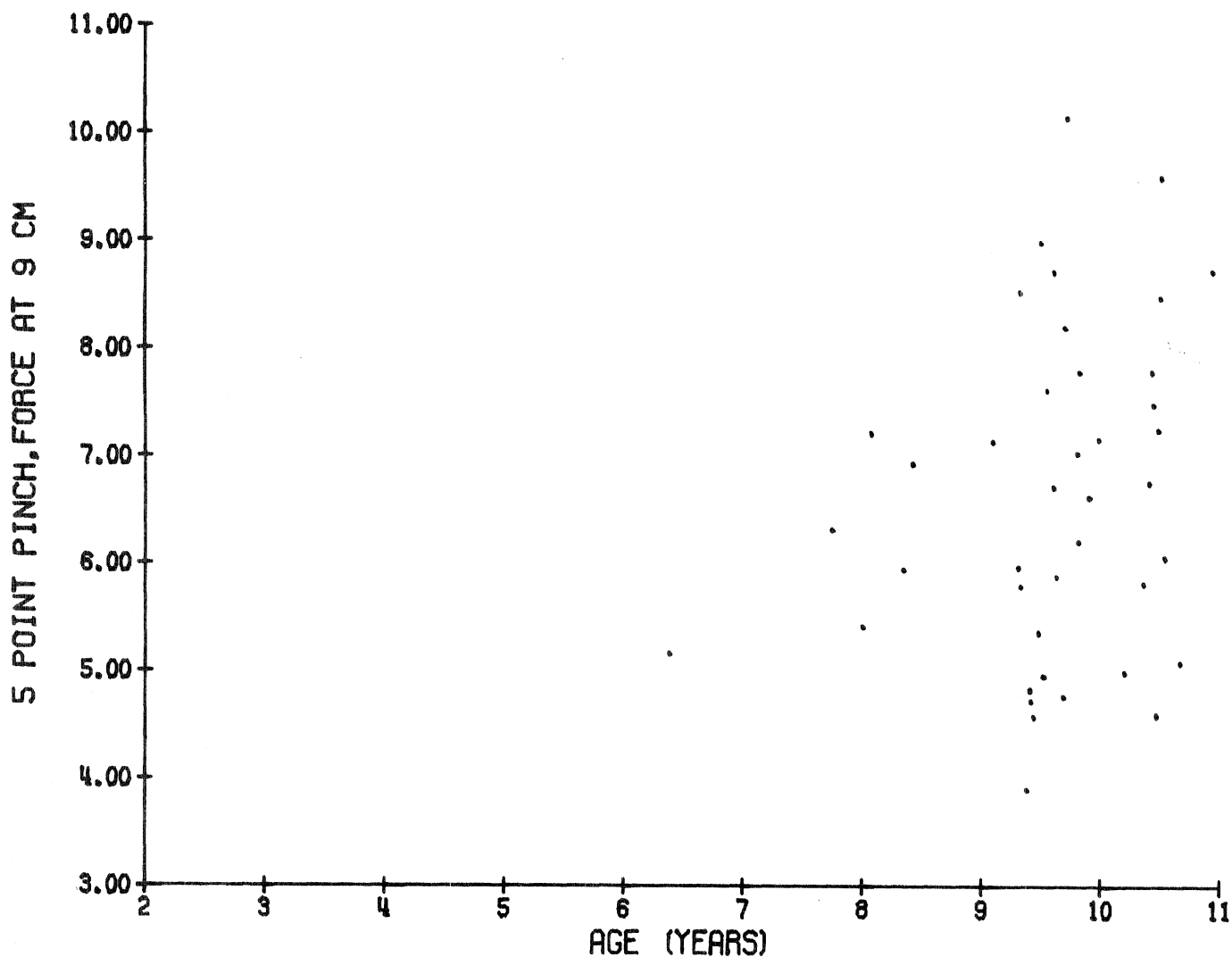
5 POINT PINCH, angle at 8 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
3.5-4.5	1	-2.1	**	-2.1	**	-2.1	**	-2.1
4.5-5.5	4	-2.8	0.3	-3.1	**	-2.9	**	-2.4
5.5-6.5	8	0.2	3.4	-5.2	**	0.2	**	6.4
6.5-7.5	20	-1.1	3.4	-6.1	**	-1.4	**	5.3
7.5-8.5	29	0.4	2.1	-4.1	-3.7	0.3	3.5	5.2
8.5-9.5	34	1.0	2.4	-4.6	-3.6	1.2	4.6	5.5
9.5-10.5	42	1.2	2.5	-3.8	-3.0	0.8	4.5	7.5



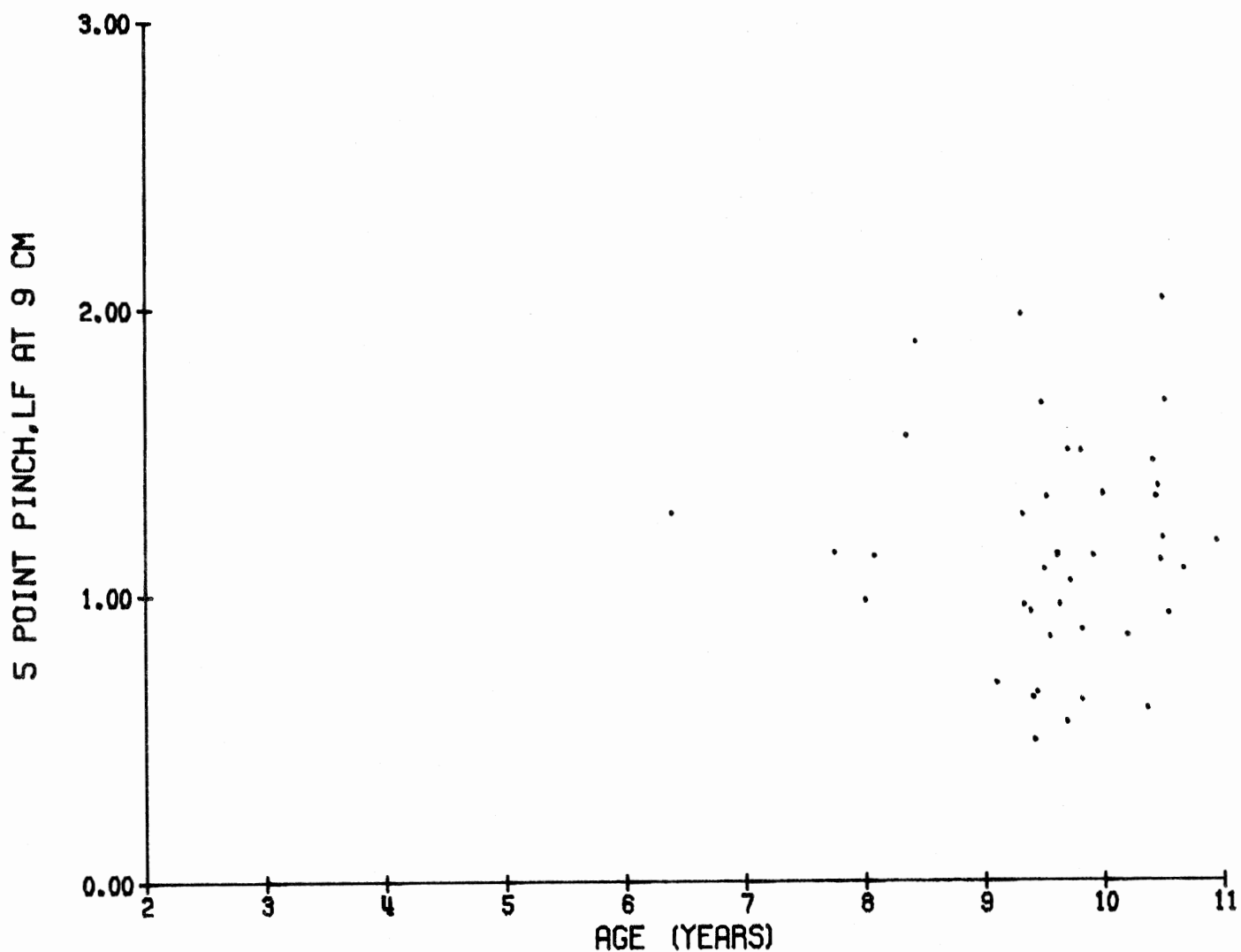
5 POINT PINCH, force at 9 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	5.2	**	5.2	**	5.2	**	5.2
7.5-8.5	5	6.3	0.7	5.4	**	6.1	**	7.2
8.5-9.5	10	6.0	1.7	3.9	**	5.3	**	9.0
9.5-10.5	25	7.0	1.5	4.6	4.6	6.9	9.3	10.1



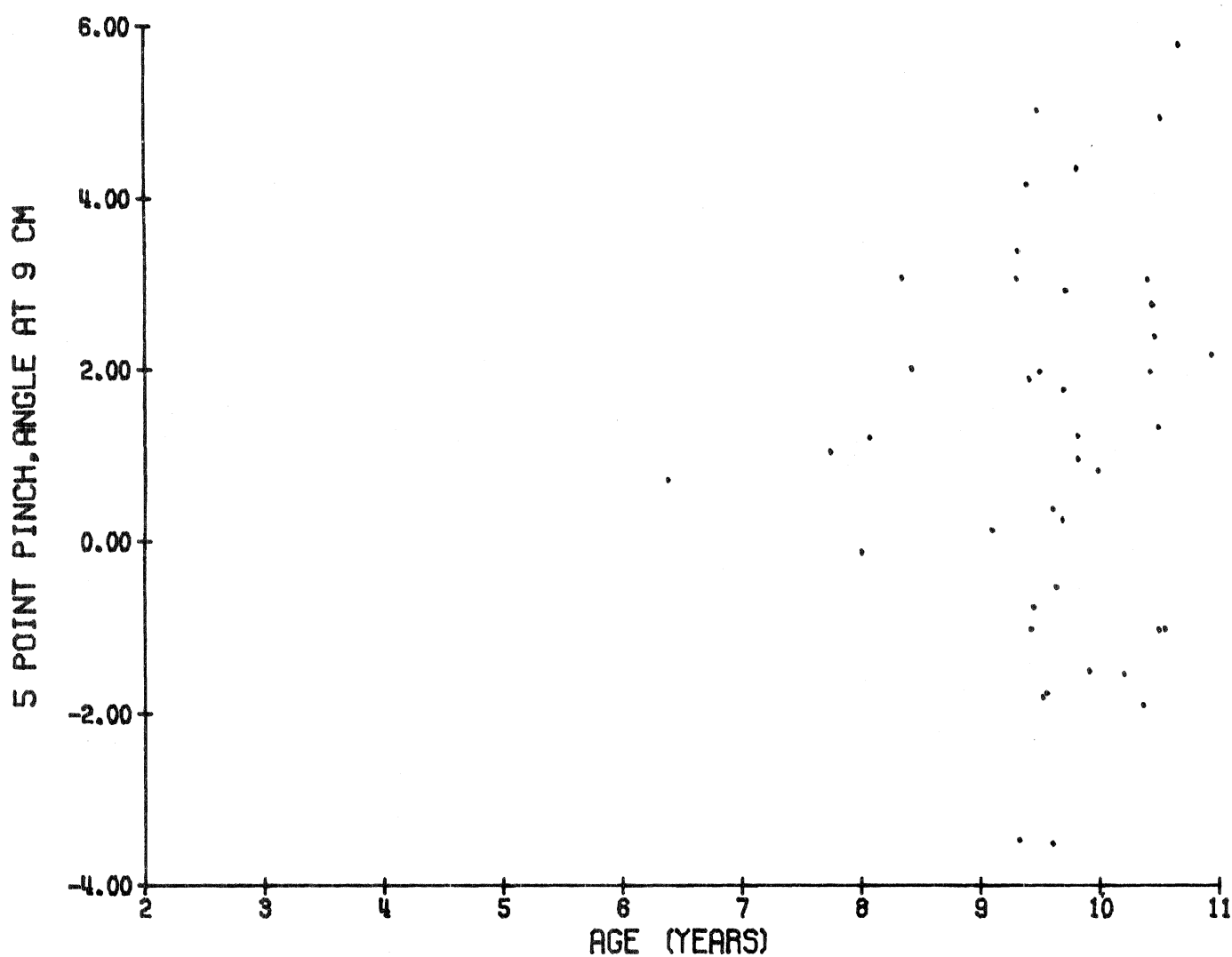
5 POINT PINCH, force location at 9 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	1.3	**	1.3	**	1.3	**	1.3
6.5-7.5	0	*****		*****	**	*****	**	-*****
7.5-8.5	5	1.3	0.4	1.0	**	1.1	**	1.9
8.5-9.5	10	1.0	0.5	0.5	**	0.9	**	2.0
9.5-10.5	25	1.2	0.3	0.6	0.6	1.1	1.6	2.0



5 POINT PINCH, angle at 9 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
5.5-6.5	1	0.7	**	0.7	**	0.7	**	0.7
7.5-8.5	5	1.4	1.2	-0.1	**	1.1	**	3.0
8.5-9.5	10	1.4	2.7	-3.5	**	1.9	**	5.0
9.5-10.5	25	0.9	2.4	-3.5	-3.1	0.9	4.7	5.7



## GRIP: SQUEEZE

**DESCRIPTION OF TEST:** The anterior surfaces of the second knuckles (proximal interphalangeal joints) of all four fingers (phalanges #2-#5) are pressed in opposition to the second knuckle of the thumb (phalanx #1).

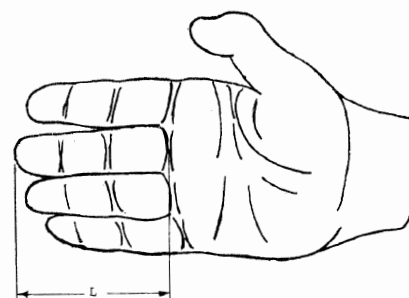
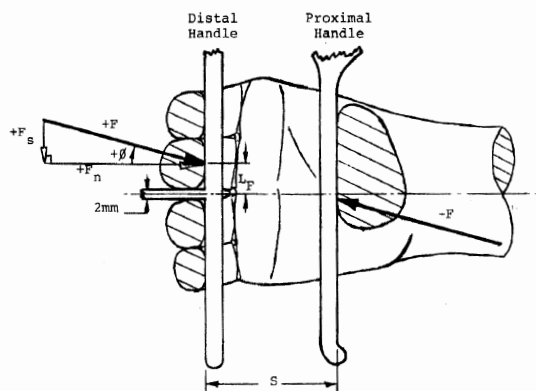
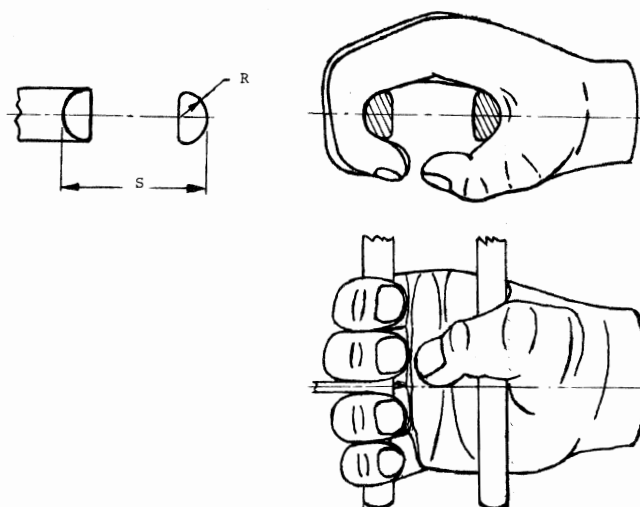
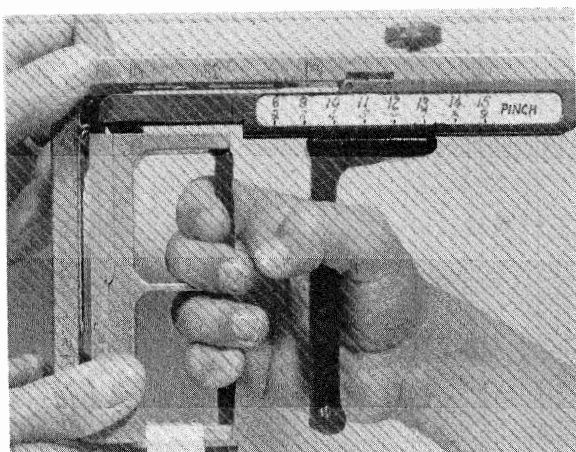
**TEST POSITION:** The handle brace lies between the second and third fingers. The wrist is left in neutral position. The thumb tip is allowed to overlap finger tips, if necessary.

**ANTHROPOMETRIC MEASUREMENT:** The length of the second finger (L) is measured from the tip to its palmar skinfold.

**ADJUSTMENT OF EQUIPMENT:** The handle set is chosen according to the following table and inserted into the transducer. The handle span (S) is then adjusted to the proper test position.

Finger Length (L) (cm)	Handle Radius (R) (mm)
<5	5
5-6	7
>6	9

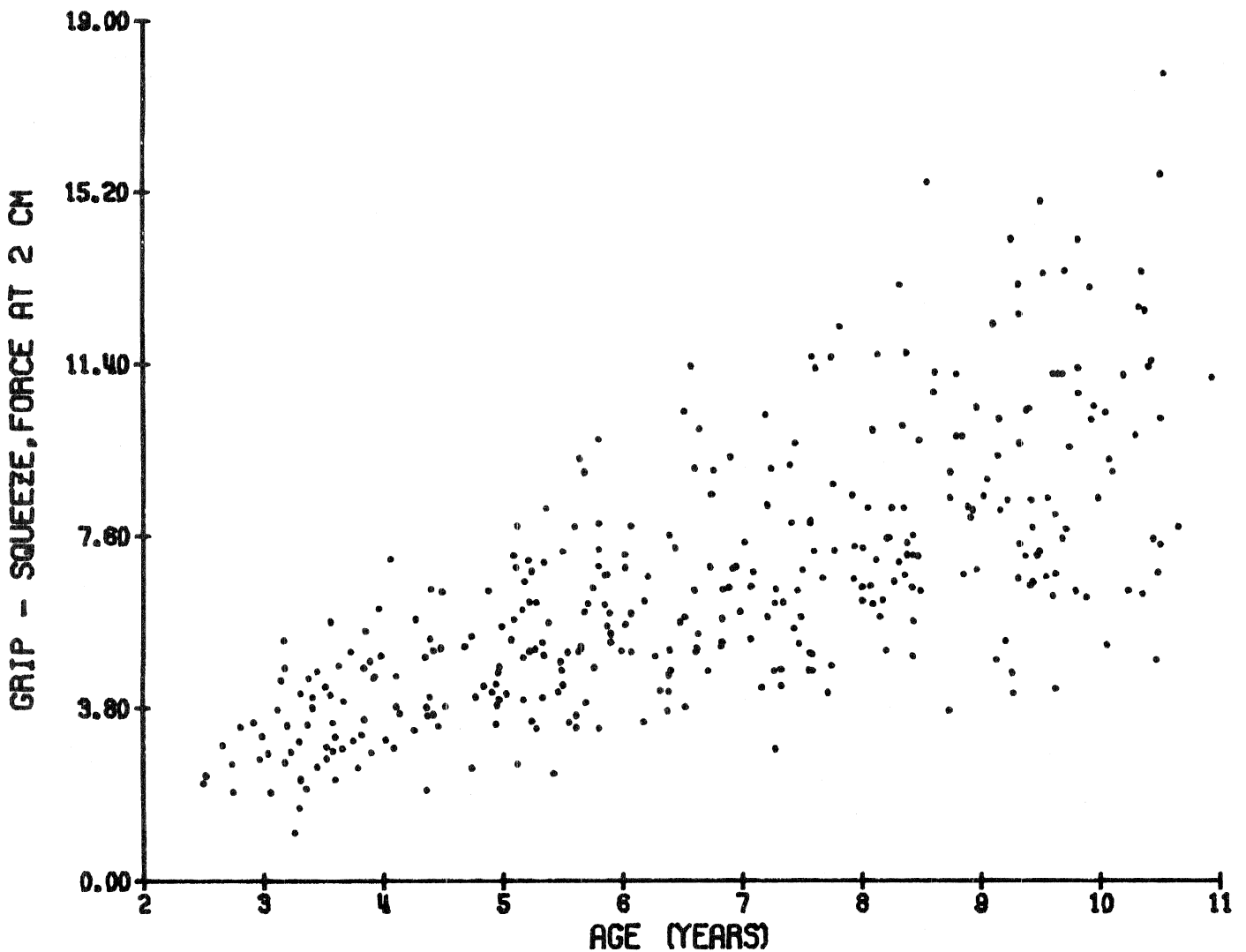
**INSTRUCTIONS TO SUBJECT:** The child squeezes the handle of the grip fixture together with his entire hand.





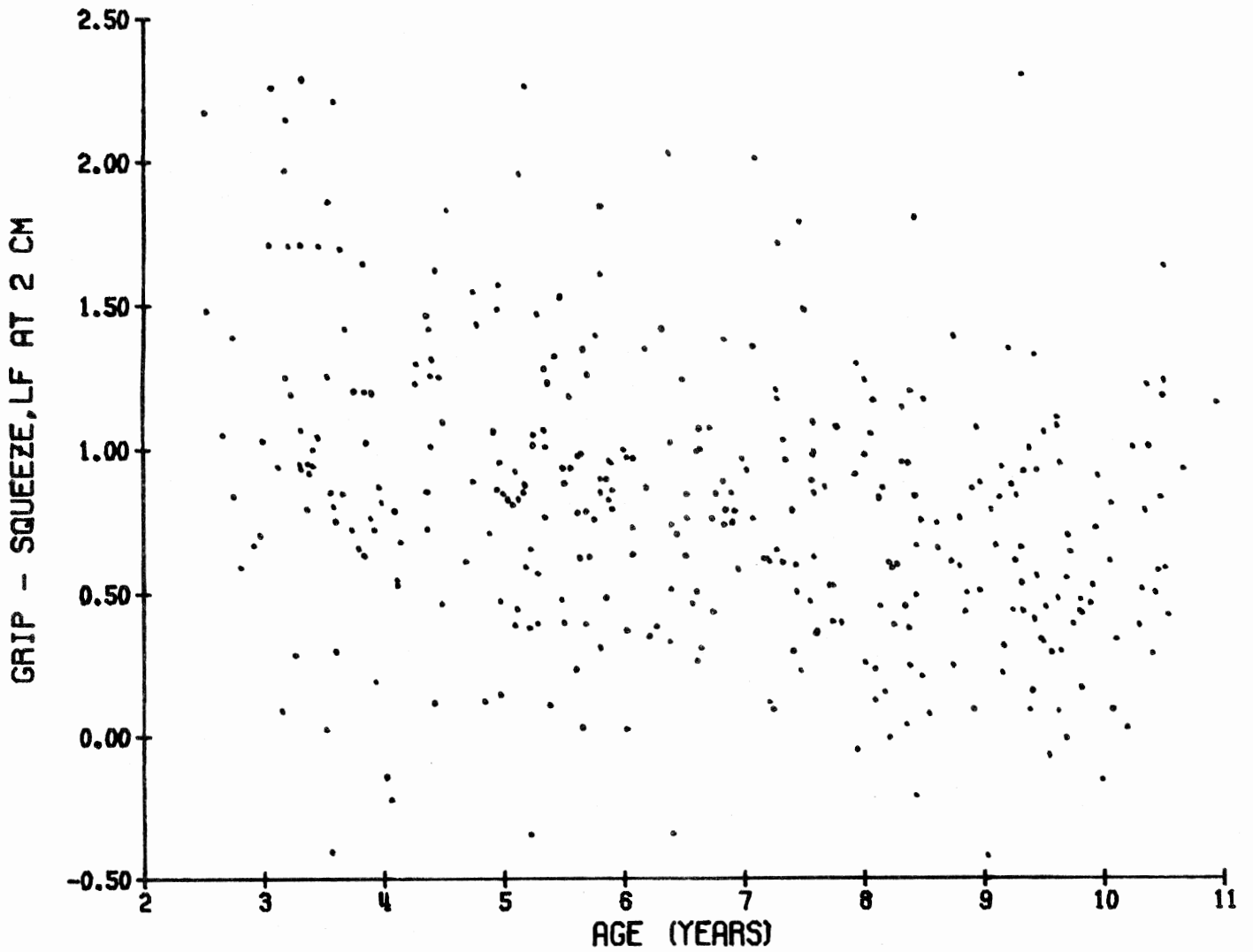
**GRIP - SQUEEZE, force at 2 cm (Kgf)**  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	3.1	1.0	1.0	1.4	2.9	4.6	5.3
3.5-4.5	45	4.1	1.2	2.0	2.3	3.9	6.3	7.1
4.5-5.5	44	5.0	1.4	2.4	2.5	4.9	7.1	8.2
5.5-6.5	49	5.8	1.6	3.4	3.4	5.6	8.5	9.7
6.5-7.5	46	6.7	2.0	2.9	4.0	6.4	10.2	11.4
7.5-8.5	52	7.6	2.2	4.1	4.6	7.2	11.6	13.1
8.5-9.5	42	8.9	2.8	3.8	4.2	8.4	14.1	15.4
9.5-10.5	45	9.7	3.0	4.2	5.0	9.7	14.0	17.8



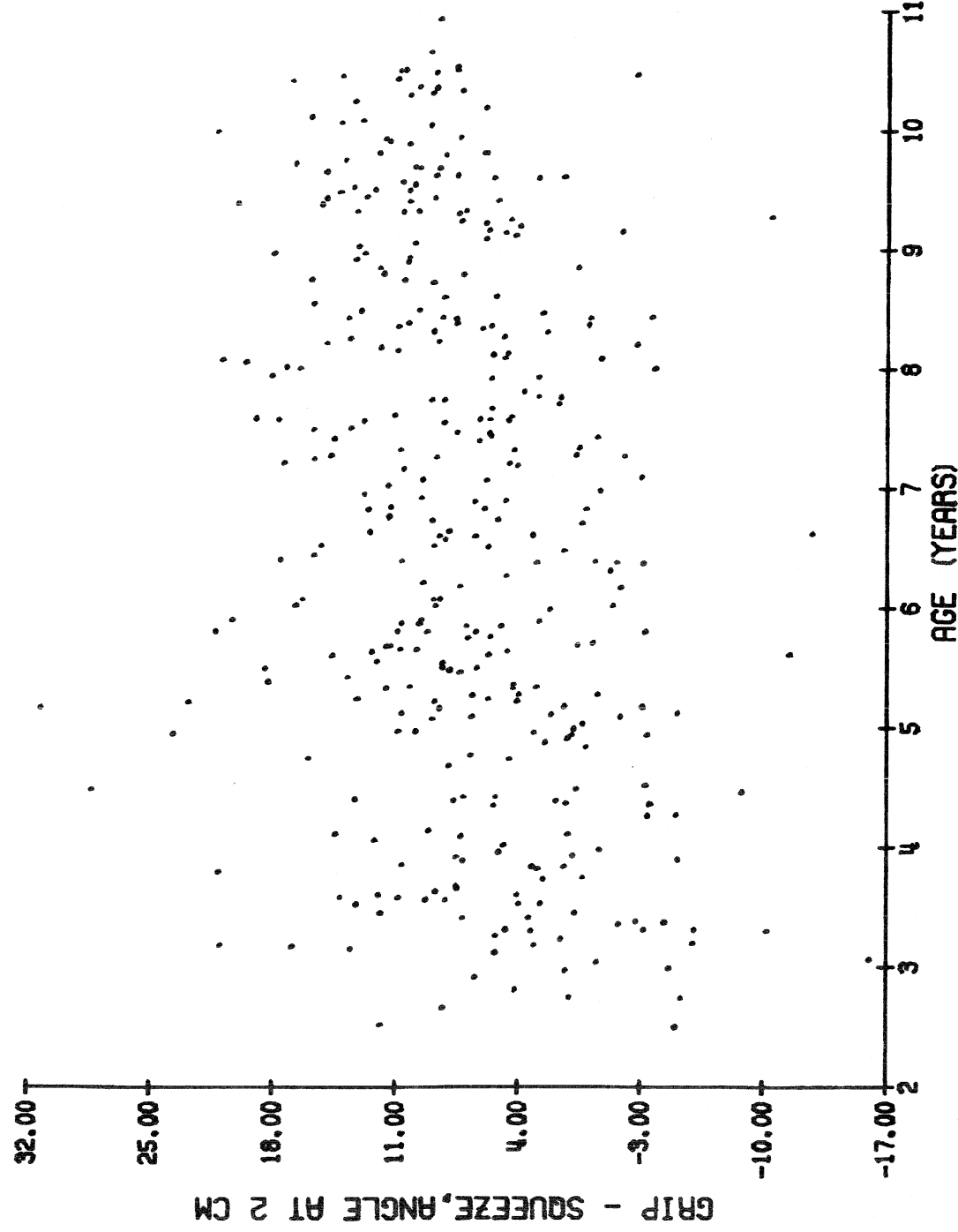
GRIP - SQUEEZE, force location at 2 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	1.2	0.6	0.1	0.2	1.0	2.2	2.3
3.5-4.5	45	0.9	0.6	-0.4	-0.2	0.8	1.7	2.2
4.5-5.5	44	0.9	0.5	-0.3	0.1	0.9	1.8	2.3
5.5-6.5	49	0.8	0.5	-0.3	0.0	0.8	1.5	2.0
6.5-7.5	46	0.8	0.4	0.1	0.2	0.8	1.7	2.0
7.5-8.5	52	0.7	0.4	-0.2	-0.0	0.6	1.3	1.8
8.5-9.5	42	0.7	0.5	-0.4	0.1	0.6	1.4	2.3
9.5-10.5	45	0.6	0.4	-0.1	-0.0	0.5	1.2	1.6



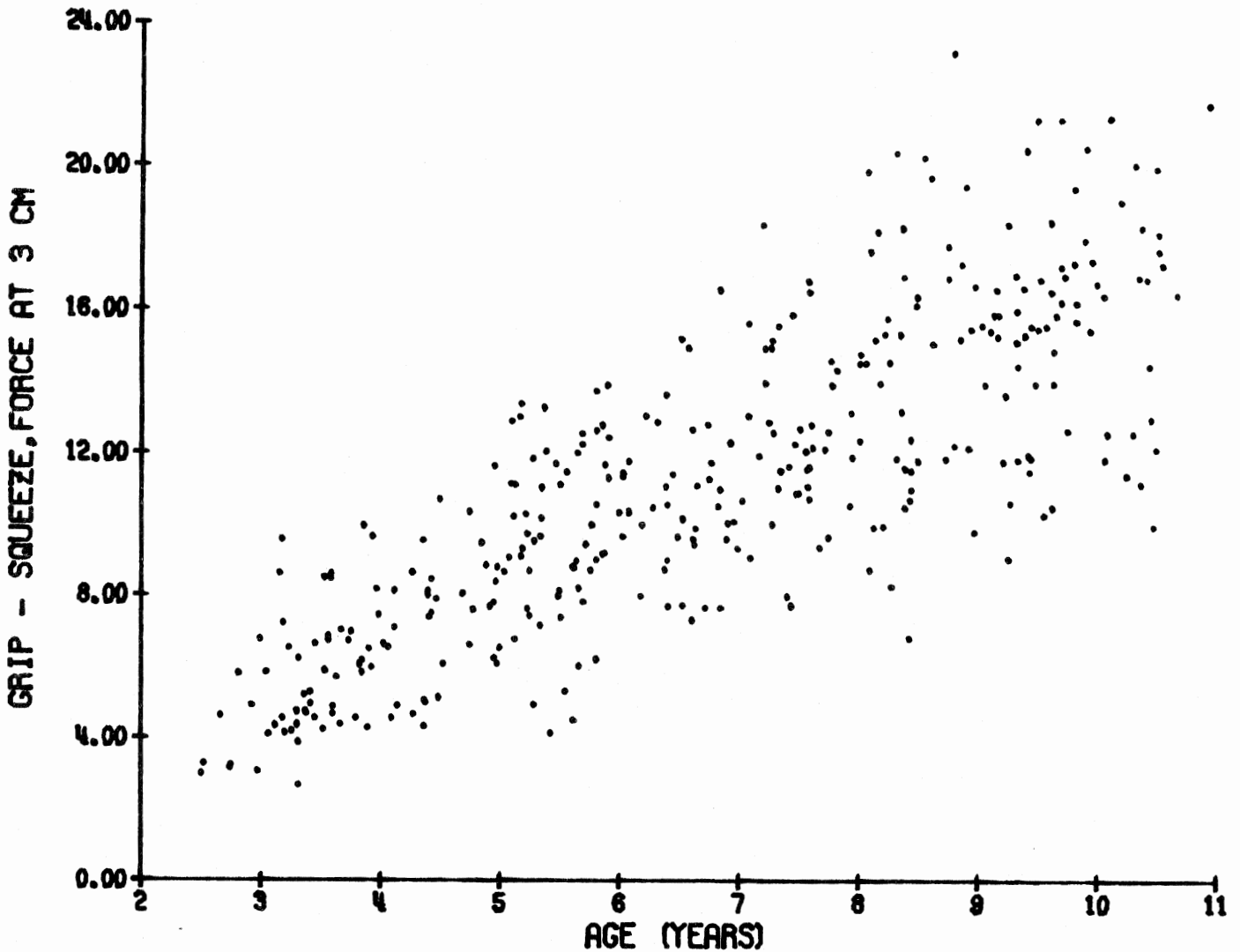
GRIP - SQUEEZE, angle at 2 cm (Degrees)  
(Males and Females)

Age (Yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	2.1	8.0	-16.1	-12.9	1.4	15.0	21.0
3.5-4.5	45	5.6	6.9	-8.8	-5.1	5.2	14.3	28.3
4.5-5.5	44	6.9	7.7	-5.1	-3.4	5.7	21.9	31.2
5.5-6.5	49	7.1	6.6	-11.5	-3.2	7.8	17.1	21.2
6.5-7.5	46	6.9	5.9	-12.8	-2.7	6.5	15.5	17.3
7.5-8.5	52	7.9	6.1	-3.8	-3.1	7.5	18.4	20.8
8.5-9.5	42	9.1	5.5	-10.4	-1.7	9.9	15.8	20.0
9.5-10.5	45	9.9	4.2	-2.7	1.8	9.6	16.4	21.1



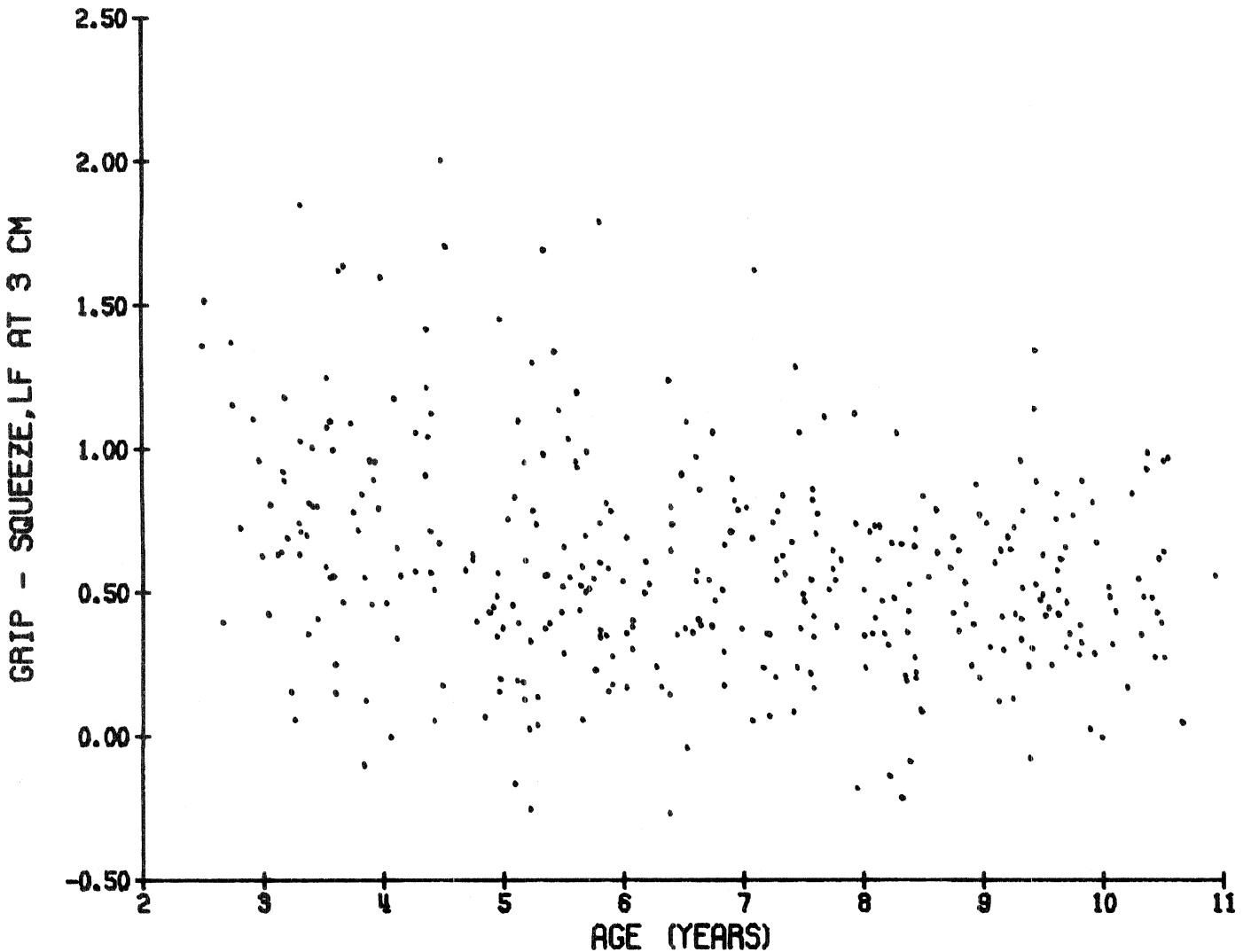
GRIP - SQUEEZE, force at 3 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	5.0	1.6	2.7	2.8	4.6	7.8	9.6
3.5-4.5	45	6.7	1.7	4.2	4.3	6.7	9.6	10.7
4.5-5.5	44	9.1	2.3	4.1	5.2	8.8	13.0	13.4
5.5-6.5	49	10.1	2.2	4.5	5.6	10.3	13.4	13.9
6.5-7.5	46	11.7	2.7	7.3	7.7	11.1	15.8	18.4
7.5-8.5	52	13.2	3.0	6.8	8.6	12.6	18.2	20.4
8.5-9.5	42	15.3	3.2	9.1	9.9	15.4	20.5	23.2
9.5-10.5	45	16.1	3.1	10.0	10.3	16.5	21.1	21.8



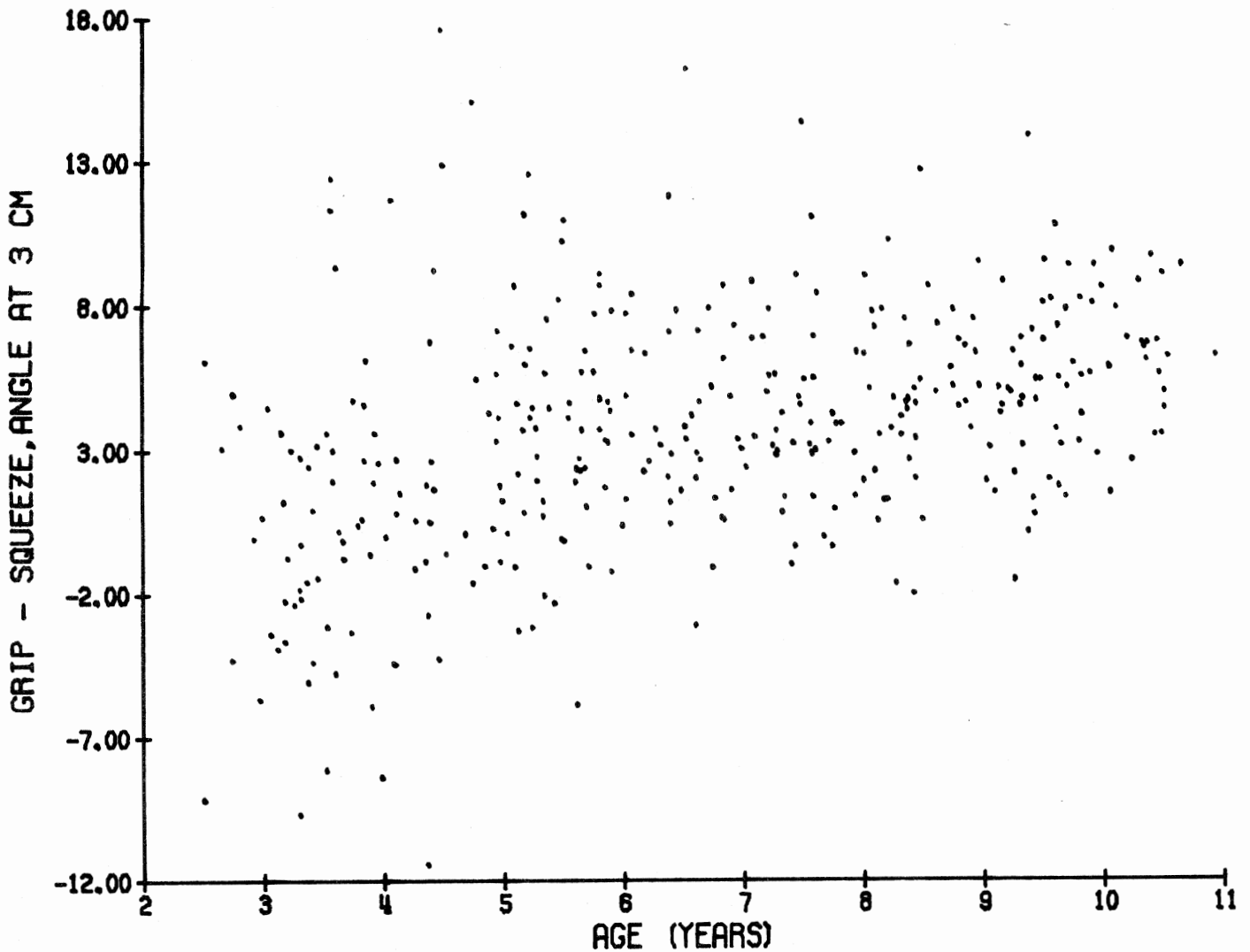
GRIP - SQUEEZE, force location at 3 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	0.8	0.4	0.1	0.1	0.8	1.4	1.8
3.5-4.5	45	0.8	0.5	-0.1	0.0	0.7	1.6	2.0
4.5-5.5	44	0.6	0.5	-0.3	-0.1	0.5	1.4	1.7
5.5-6.5	49	0.6	0.4	-0.3	0.1	0.5	1.1	1.8
6.5-7.5	46	0.6	0.3	-0.0	0.1	0.5	1.1	1.6
7.5-8.5	52	0.5	0.3	-0.2	-0.2	0.5	0.9	1.1
8.5-9.5	42	0.5	0.3	-0.1	0.1	0.5	0.9	1.3
9.5-10.5	45	0.5	0.3	-0.0	0.0	0.5	0.9	1.0



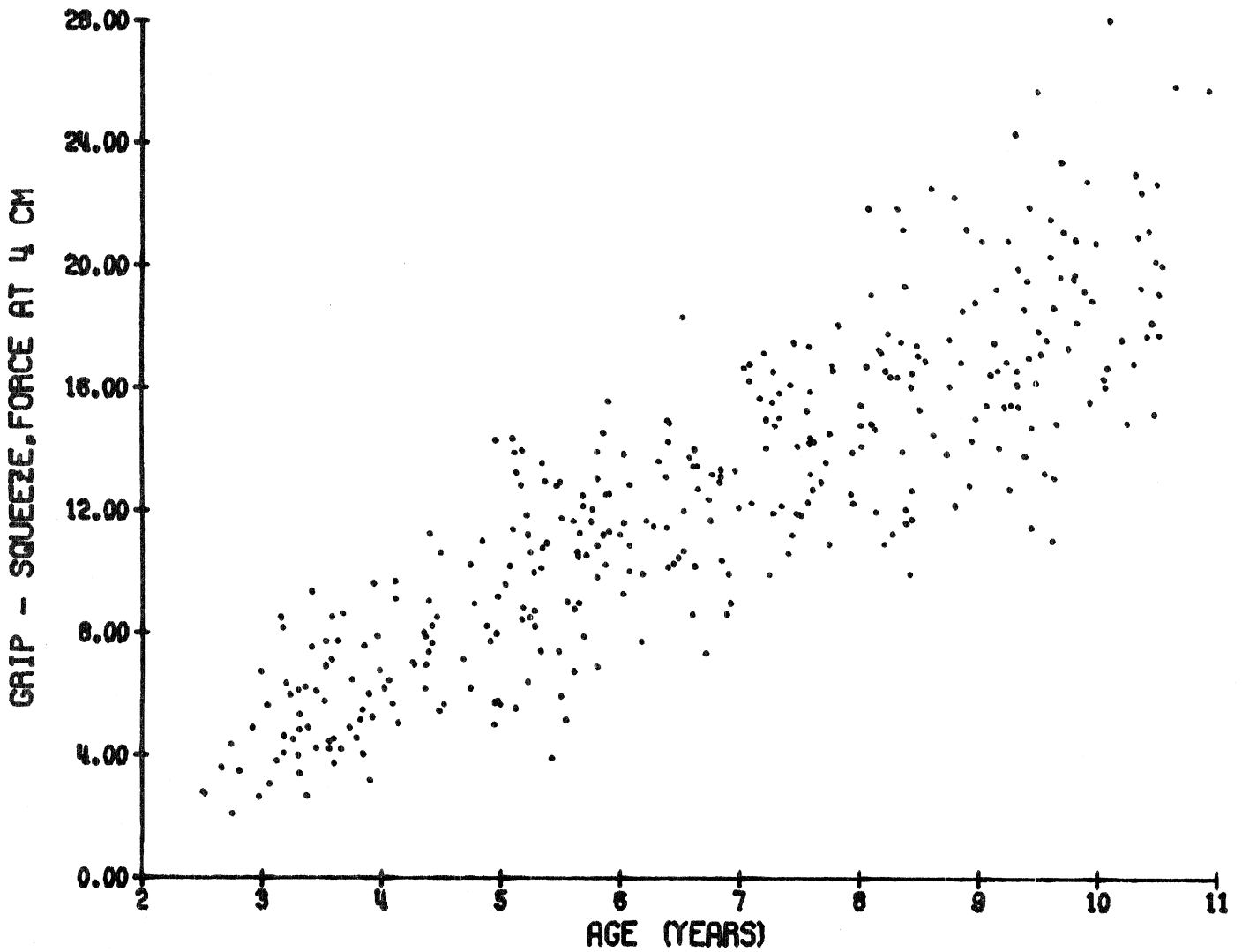
GRIP - SQUEEZE, angle at 3 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	-0.7	4.0	-9.6	-9.4	-1.1	4.7	6.1
3.5-4.5	45	1.8	5.9	-11.4	-8.3	1.2	12.3	17.7
4.5-5.5	44	3.5	4.3	-3.2	-3.0	3.3	11.0	15.1
5.5-6.5	49	4.0	3.3	-5.8	-1.1	3.7	9.0	11.9
6.5-7.5	46	4.4	3.6	-3.0	-1.0	3.7	9.1	16.3
7.5-8.5	52	4.3	3.1	-1.9	-0.8	4.0	9.6	12.8
8.5-9.5	42	5.3	2.8	-1.4	0.3	5.2	8.9	14.0
9.5-10.5	45	6.3	2.6	1.5	1.7	6.3	9.8	10.9



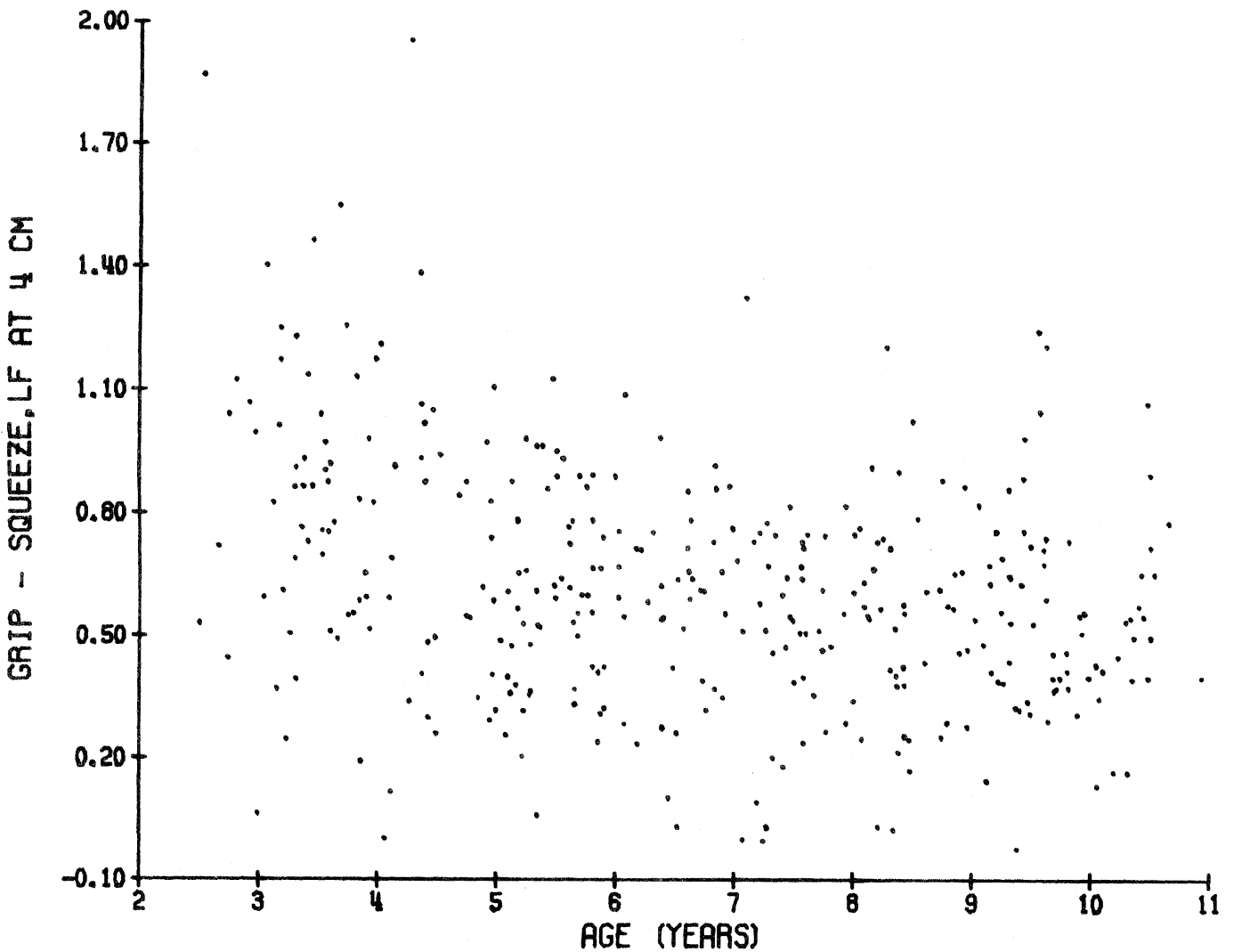
GRIP - SQUEEZE, force at 4 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	4.9	1.8	2.1	2.4	4.5	8.3	9.3
3.5-4.5	45	6.7	1.9	3.2	3.8	6.8	9.6	11.2
4.5-5.5	44	9.5	2.9	3.9	5.1	9.1	13.9	14.3
5.5-6.5	49	11.0	2.3	5.1	6.3	11.2	14.7	15.5
6.5-7.5	46	13.1	2.6	7.3	8.6	13.1	17.0	18.3
7.5-8.5	52	15.0	2.8	9.9	10.9	14.7	20.0	21.8
8.5-9.5	42	17.2	3.3	11.4	12.2	16.5	22.4	25.6
9.5-10.5	45	19.1	3.5	11.0	13.1	19.0	25.0	27.9



GRIP - SQUEEZE, force location at 4 cm  
(Males and Females)

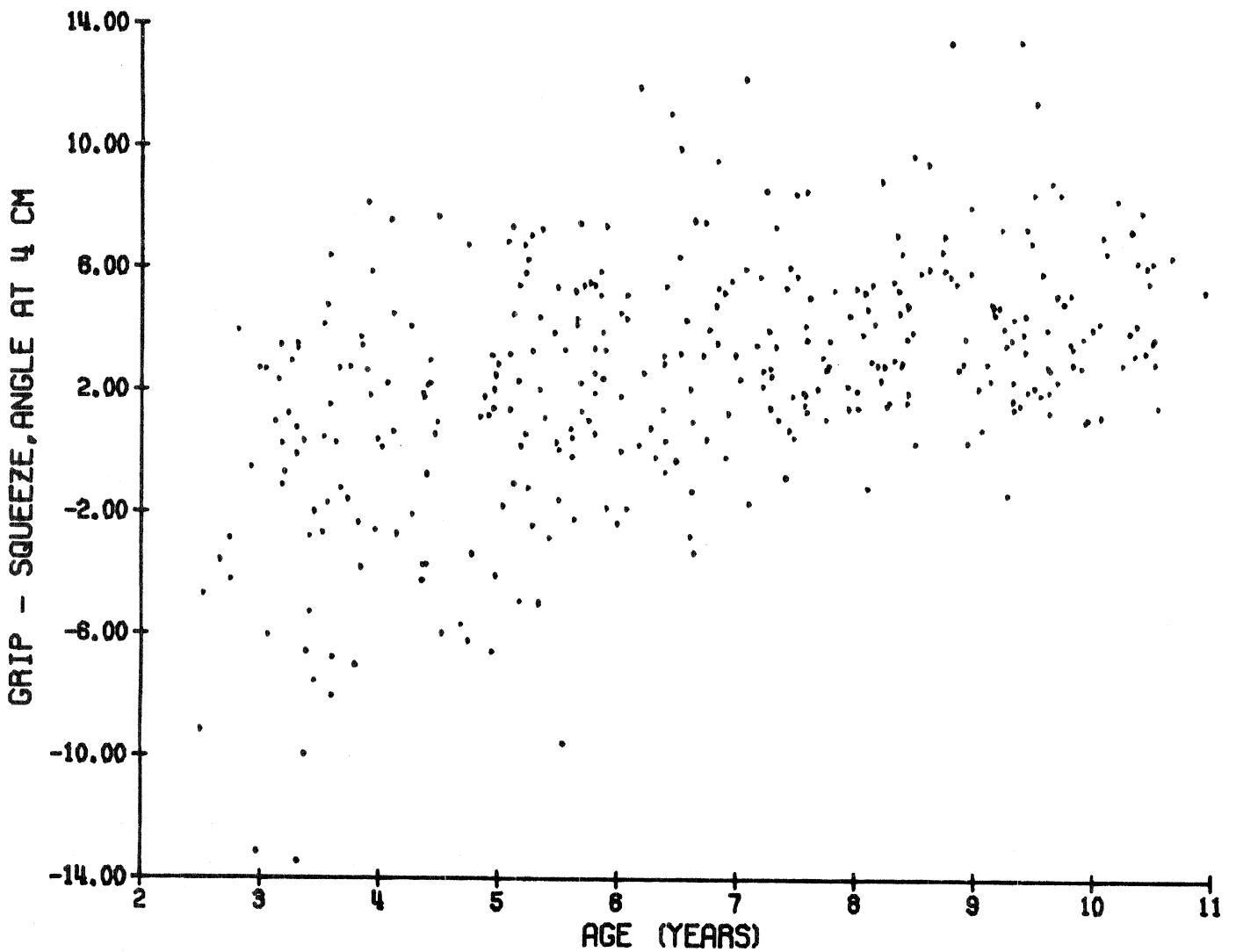
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	0.9	0.4	0.1	0.2	0.9	1.4	1.9
3.5-4.5	45	0.8	0.4	0.0	0.1	0.8	1.4	2.0
4.5-5.5	44	0.6	0.3	0.1	0.2	0.6	1.0	1.1
5.5-6.5	49	0.6	0.2	0.1	0.2	0.6	0.9	1.1
6.5-7.5	46	0.6	0.3	-0.0	0.0	0.6	0.9	1.3
7.5-8.5	52	0.5	0.2	0.0	0.1	0.5	0.9	1.2
8.5-9.5	42	0.6	0.2	-0.0	0.2	0.6	0.9	1.0
9.5-10.5	45	0.5	0.2	0.1	0.2	0.5	1.1	1.2





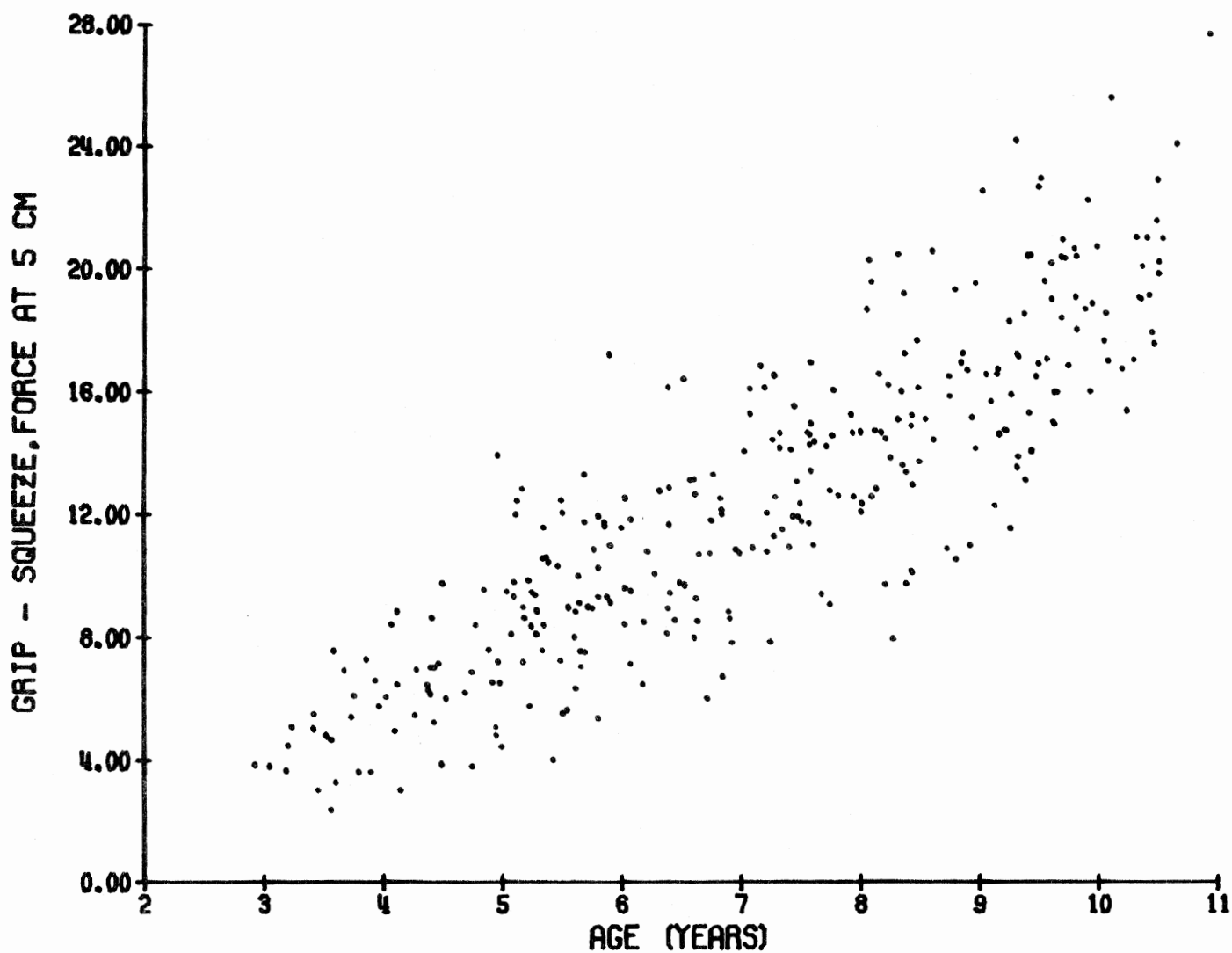
GRIP - SQUEEZE, angle at 4 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	31	-2.1	4.9	-13.4	-13.3	-0.9	3.5	3.9
3.5-4.5	45	0.7	3.8	-8.0	-7.0	0.8	7.2	8.1
4.5-5.5	44	1.2	4.2	-6.6	-6.2	1.4	7.0	7.3
5.5-6.5	49	2.4	3.6	-9.6	-2.3	2.3	7.4	11.9
6.5-7.5	46	3.6	3.4	-3.3	-2.5	3.2	9.2	12.2
7.5-8.5	52	3.6	2.2	-1.2	0.7	3.0	7.6	9.6
8.5-9.5	42	4.6	3.1	-1.4	0.3	4.3	9.3	13.4
9.5-10.5	45	4.4	2.3	1.0	1.1	3.9	8.3	11.4



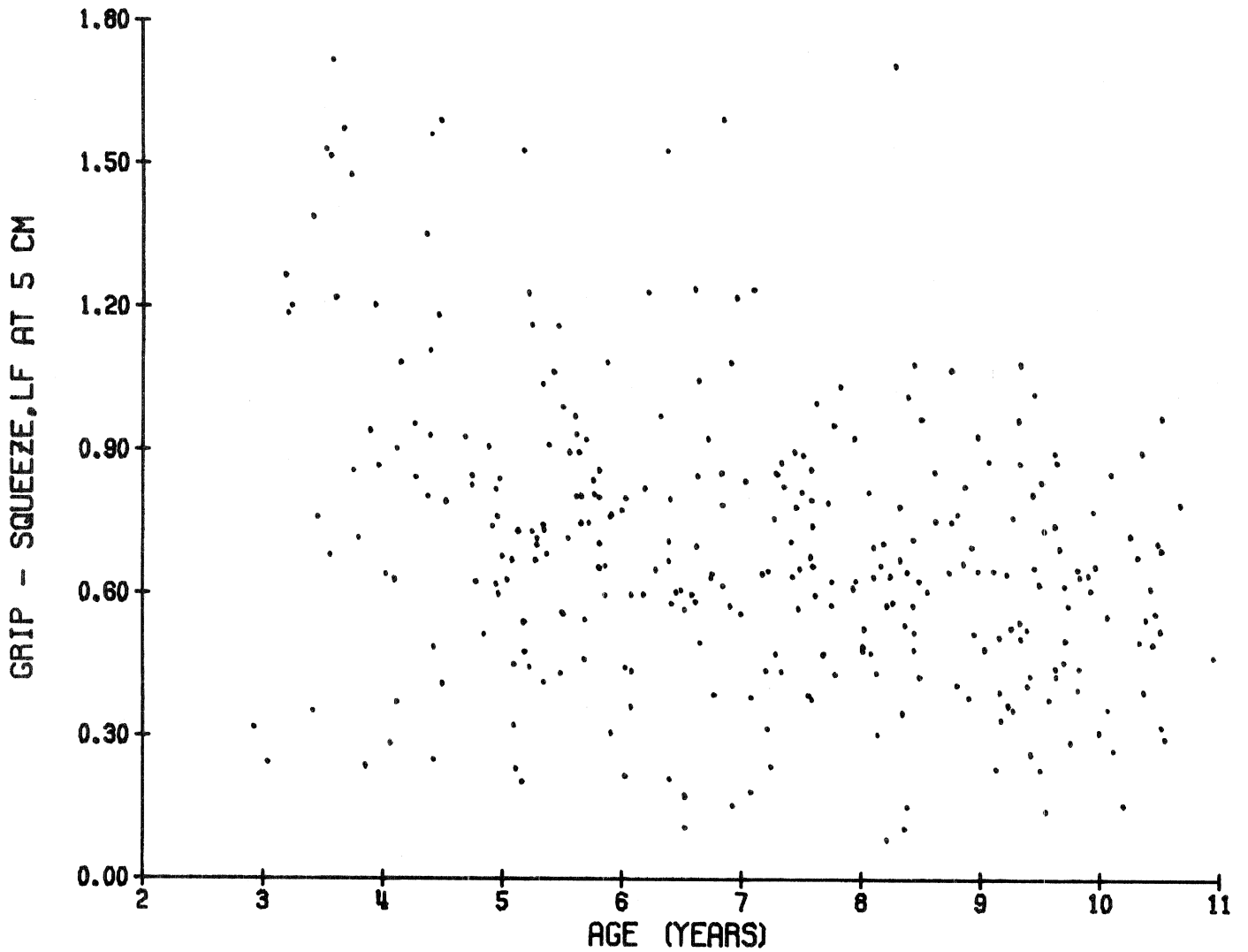
GRIP - SQUEEZE, force at 5 cm (Kgf)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	8	4.3	0.8	3.0	**	3.8	**	5.5
3.5-4.5	31	6.0	1.8	2.4	2.8	6.1	8.8	9.8
4.5-5.5	41	8.5	2.5	3.8	4.1	8.4	12.5	14.0
5.5-6.5	47	9.9	2.5	5.4	5.6	9.4	13.2	17.3
6.5-7.5	46	12.0	2.7	6.0	7.1	12.0	16.4	16.9
7.5-8.5	52	14.2	2.8	8.0	9.3	14.4	19.4	20.6
8.5-9.5	42	16.3	3.2	10.6	11.0	16.0	22.4	24.3
9.5-10.5	45	19.5	2.7	15.0	15.2	19.2	23.9	27.8



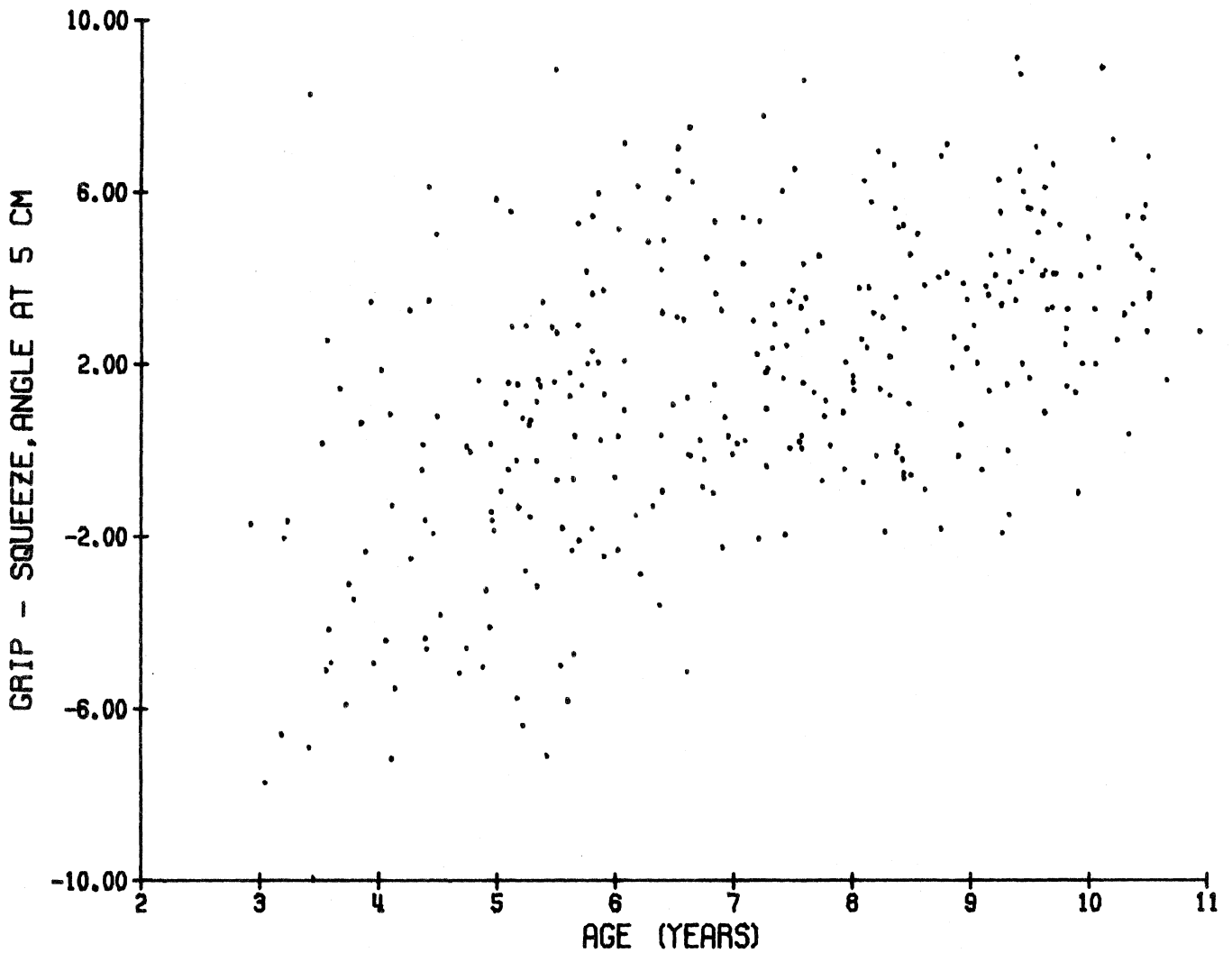
GRIP - SQUEEZE, force location at 5 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	8	0.8	0.5	0.2	**	0.8	**	1.4
3.5-4.5	31	1.0	0.4	0.2	0.2	0.9	1.6	1.7
4.5-5.5	41	0.7	0.3	0.2	0.2	0.7	1.2	1.5
5.5-6.5	47	0.7	0.2	0.2	0.2	0.7	1.0	1.5
6.5-7.5	46	0.7	0.3	0.1	0.2	0.6	1.2	1.6
7.5-8.5	52	0.6	0.3	0.1	0.1	0.6	1.0	1.7
8.5-9.5	42	0.6	0.2	0.2	0.2	0.6	1.0	1.1
9.5-10.5	45	0.6	0.2	0.1	0.2	0.6	0.9	1.0



GRIP - SQUEEZE, angle at 5 cm (Degrees)  
(Males and Females)

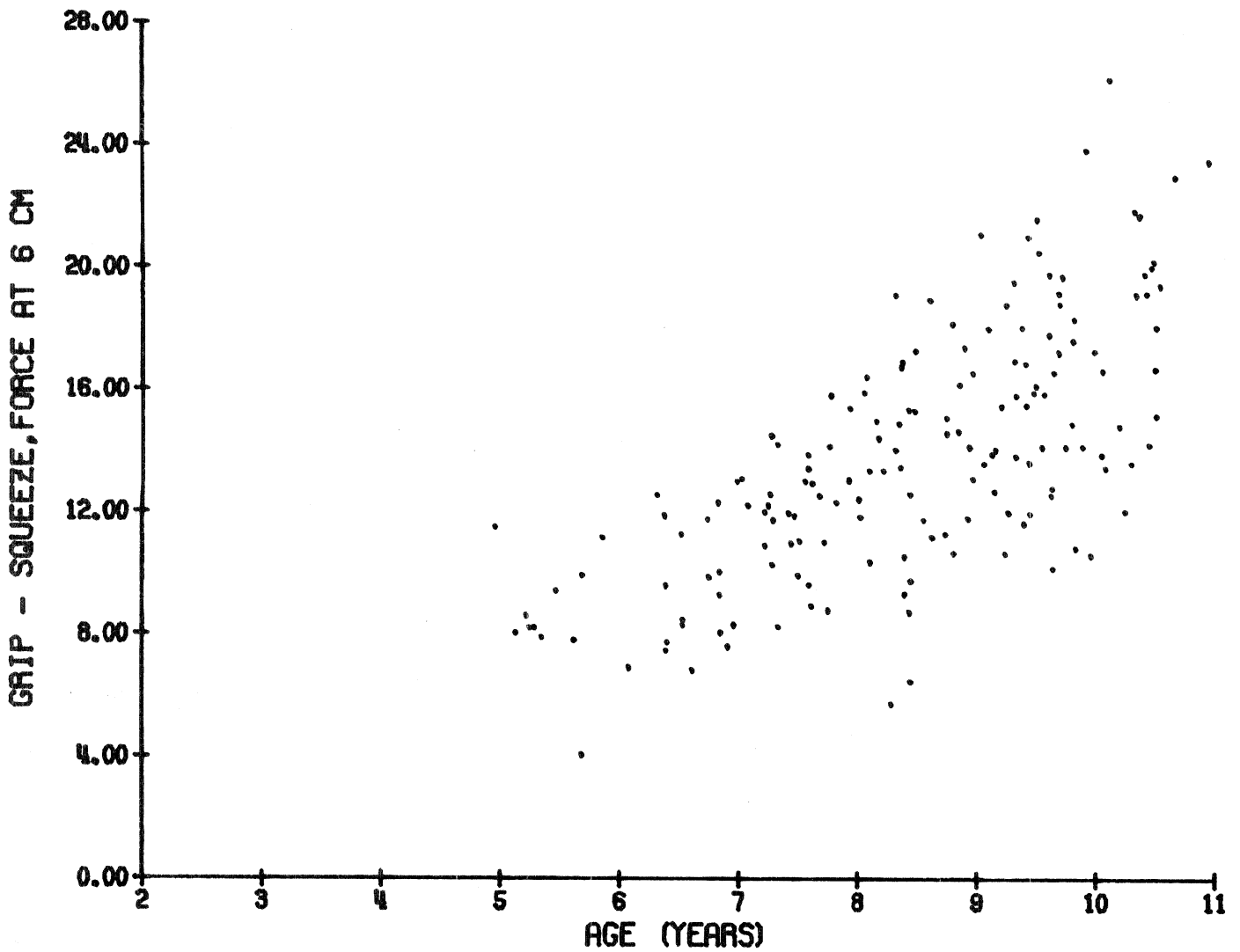
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
2.5-3.5	8	-3.5	5.7	-10.0	**	-6.6	**	8.3
3.5-4.5	31	-1.2	3.5	-7.2	-6.5	-1.8	4.2	6.1
4.5-5.5	41	-0.3	3.4	-7.1	-6.4	-0.1	5.5	8.9
5.5-6.5	47	1.1	3.3	-5.8	-4.9	1.2	6.0	7.2
6.5-7.5	46	2.2	2.9	-5.1	-2.2	1.9	6.9	7.8
7.5-8.5	52	2.4	2.4	-1.9	-0.7	1.8	6.6	8.6
8.5-9.5	42	3.4	2.7	-1.9	-1.8	3.7	7.1	9.2
9.5-10.5	45	4.0	1.9	-0.9	0.6	4.1	7.0	9.0



GRIP - SQUEEZE, force at 6 cm  
(Males and Females)

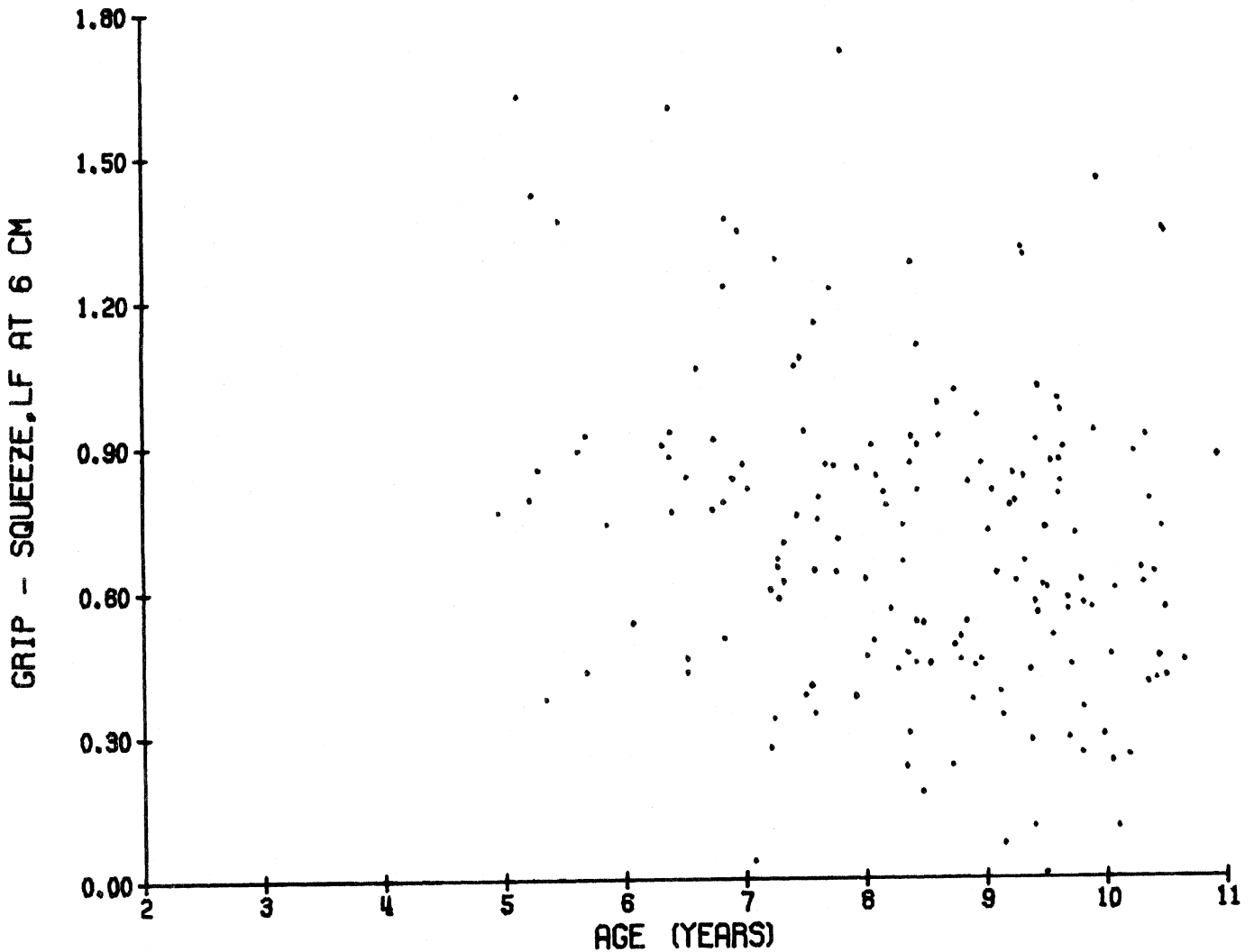
(Kgf)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
4.5-5.5	7	8.8	1.3	7.9	**	8.2	**	11.5
5.5-6.5	10	8.9	2.6	4.1	**	7.8	**	12.5
6.5-7.5	28	10.7	2.0	6.8	7.1	10.9	13.7	14.5
7.5-8.5	40	12.8	3.0	5.7	6.5	13.0	16.9	19.0
8.5-9.5	39	15.2	3.0	10.6	10.6	14.8	20.9	21.5
9.5-10.5	44	17.2	3.8	10.1	10.6	17.2	23.3	26.1



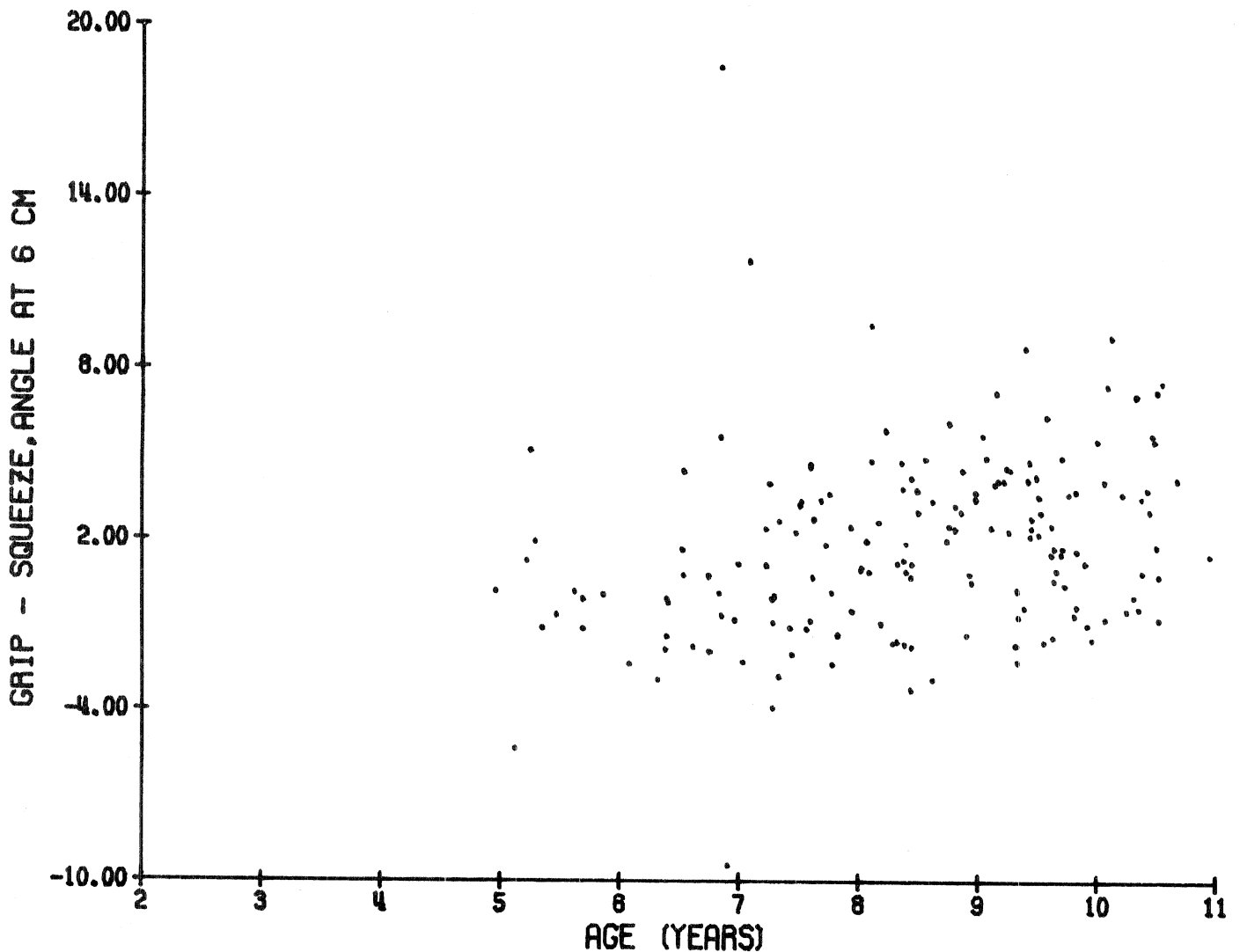
GRIP - SQUEEZE, force location at 6 cm  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
4.5-5.5	7	1.0	0.4	0.4	**	0.8	**	1.6
5.5-6.5	10	0.9	0.3	0.4	**	0.9	**	1.6
6.5-7.5	28	0.8	0.3	0.0	0.1	0.8	1.3	1.4
7.5-8.5	40	0.7	0.3	-0.1	0.2	0.7	1.2	1.7
8.5-9.5	39	0.6	0.3	0.0	0.1	0.6	1.0	1.3
9.5-10.5	44	0.6	0.3	-0.0	0.1	0.6	1.3	1.5



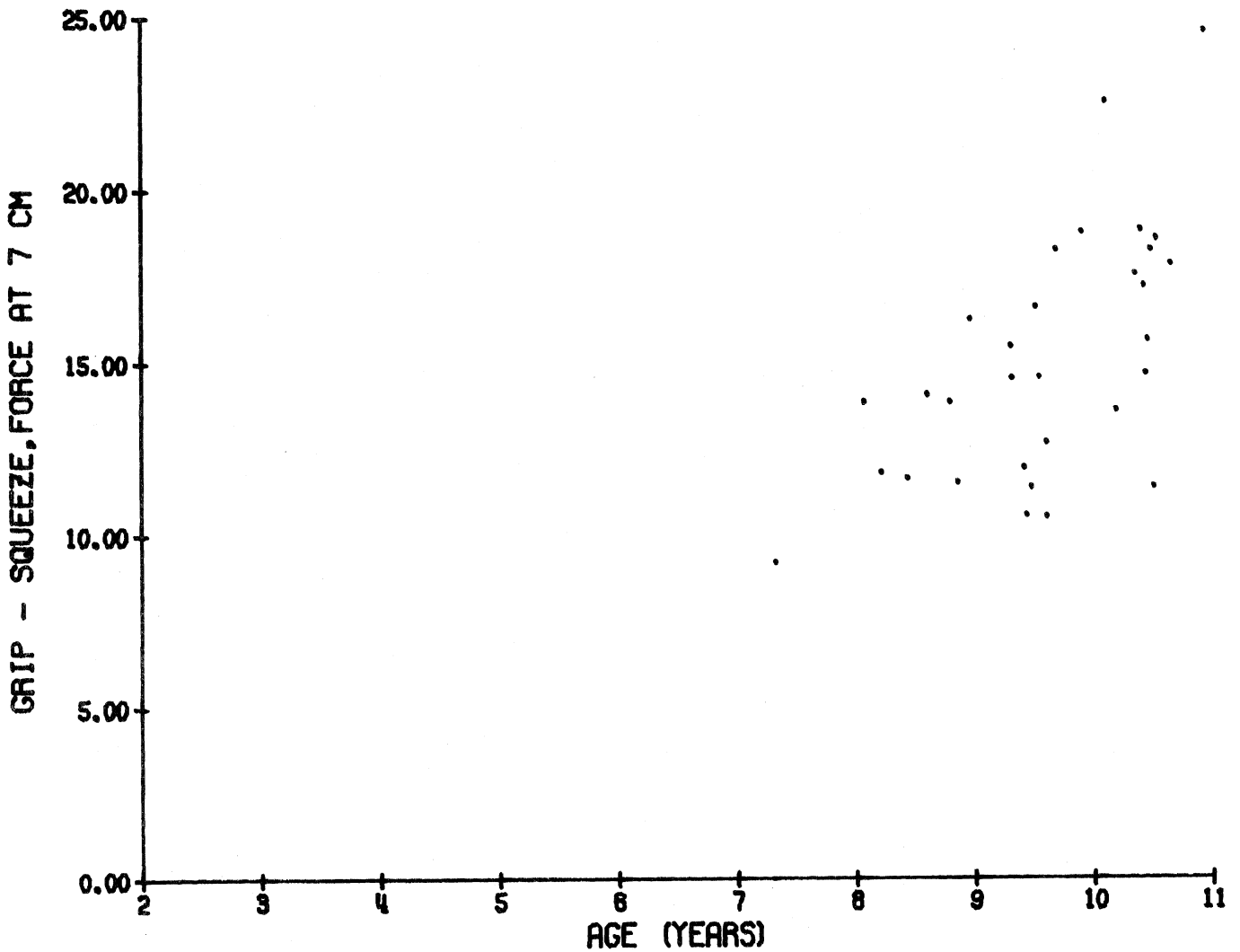
GRIP - SQUEEZE, angle at 6 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
4.5-5.5	7	0.2	3.2	-5.4	**	-0.3	**	5.1
5.5-6.5	10	-1.0	1.1	-3.0	**	-1.2	**	0.1
6.5-7.5	28	1.1	5.0	-9.5	-7.3	0.1	9.2	18.5
7.5-8.5	40	1.6	2.6	-3.3	-2.4	1.1	4.7	9.5
8.5-9.5	39	2.8	2.5	-2.9	-2.3	3.0	6.1	8.7
9.5-10.5	44	2.4	2.8	-1.6	-1.5	1.7	7.3	9.0



GRIP - SQUEEZE, force at 7 cm (Kgf)  
(Males and Females)

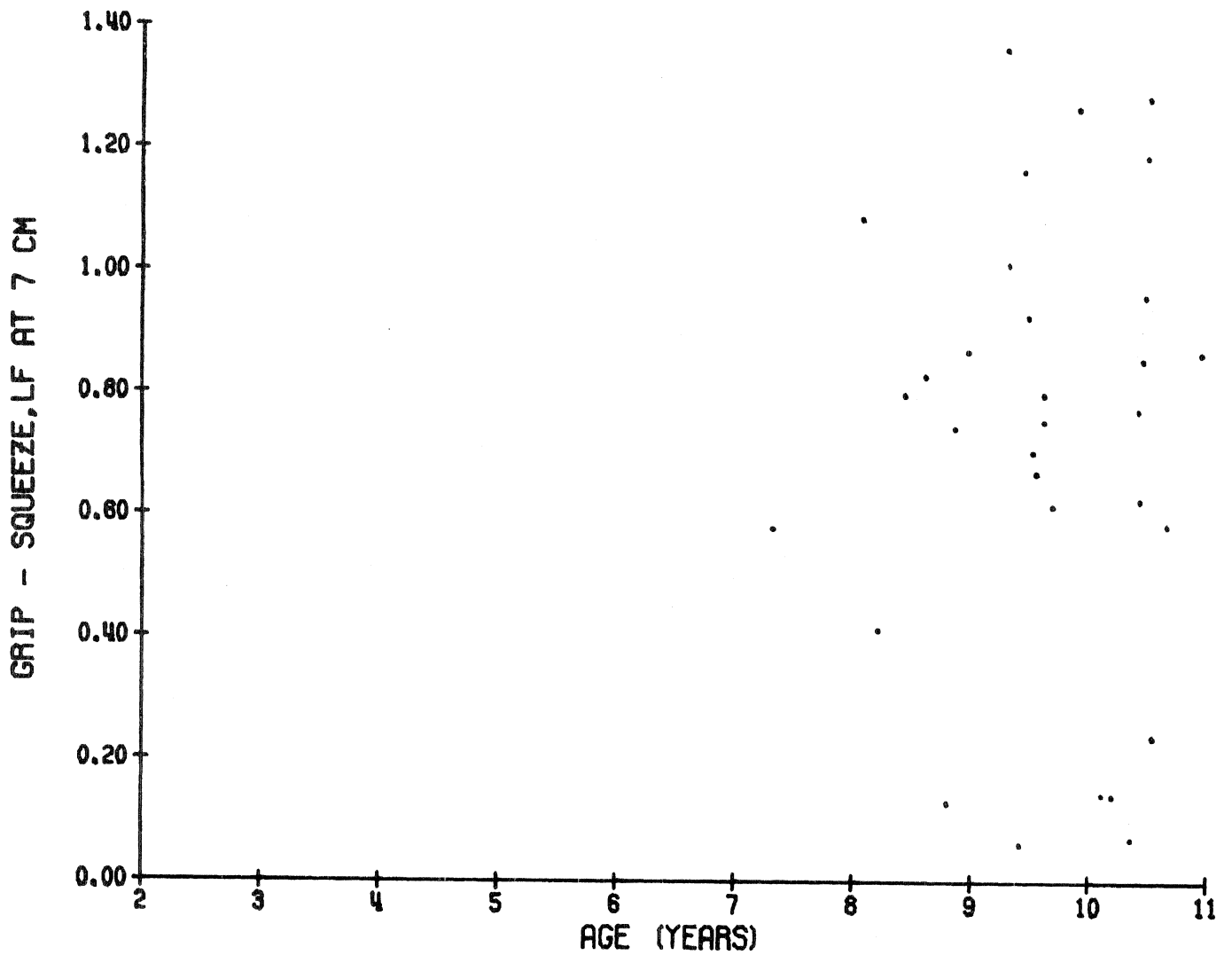
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
6.5-7.5	1	9.2	**	9.2	**	9.2	**	9.2
7.5-8.5	3	12.4	1.3	11.6	**	11.7	**	13.9
8.5-9.5	9	13.3	2.0	10.6	**	12.9	**	16.3
9.5-10.5	18	16.8	3.6	10.5	**	17.2	**	24.6





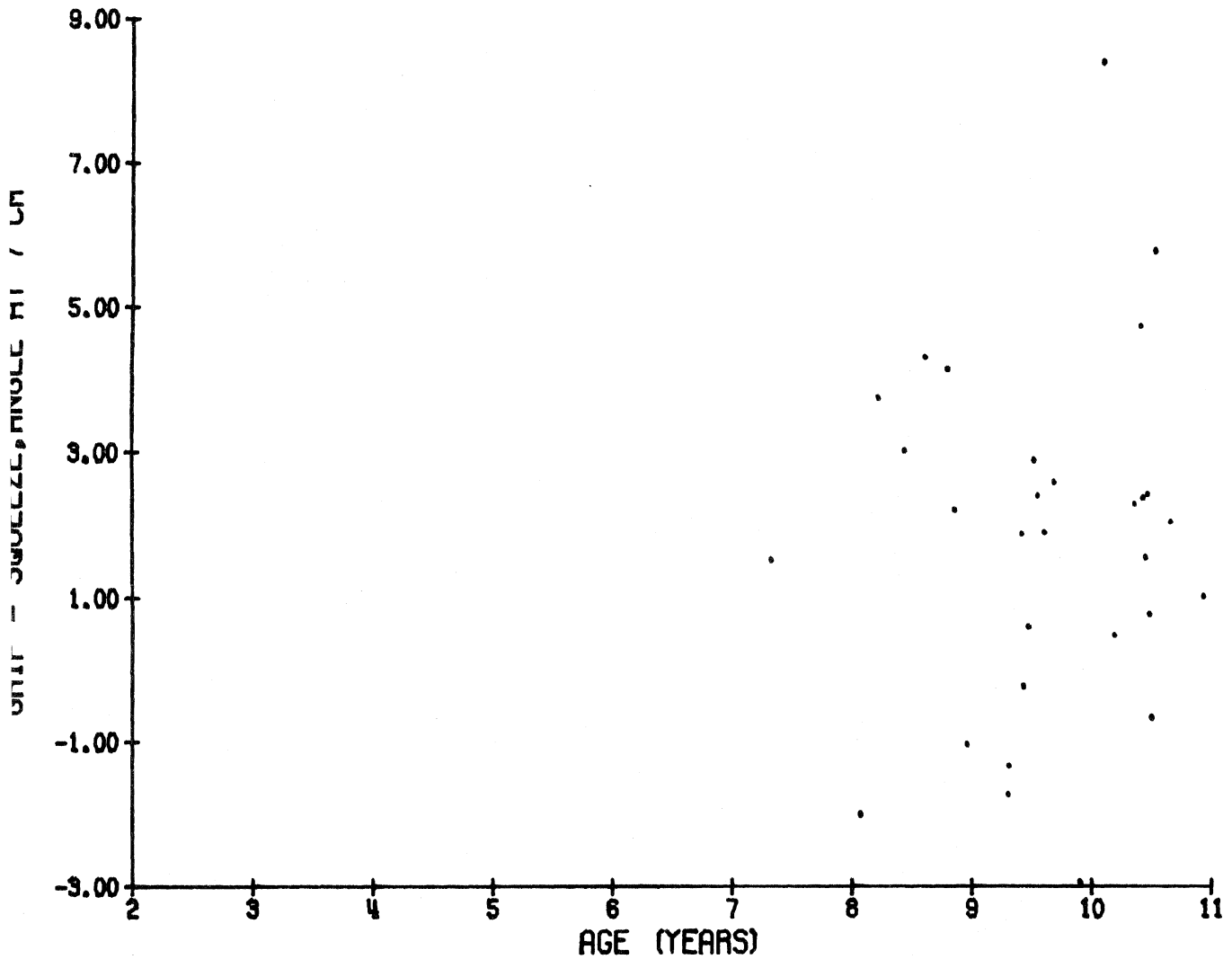
GRIP - SQUEEZE, force location at 7 cm  
(Males and Females)

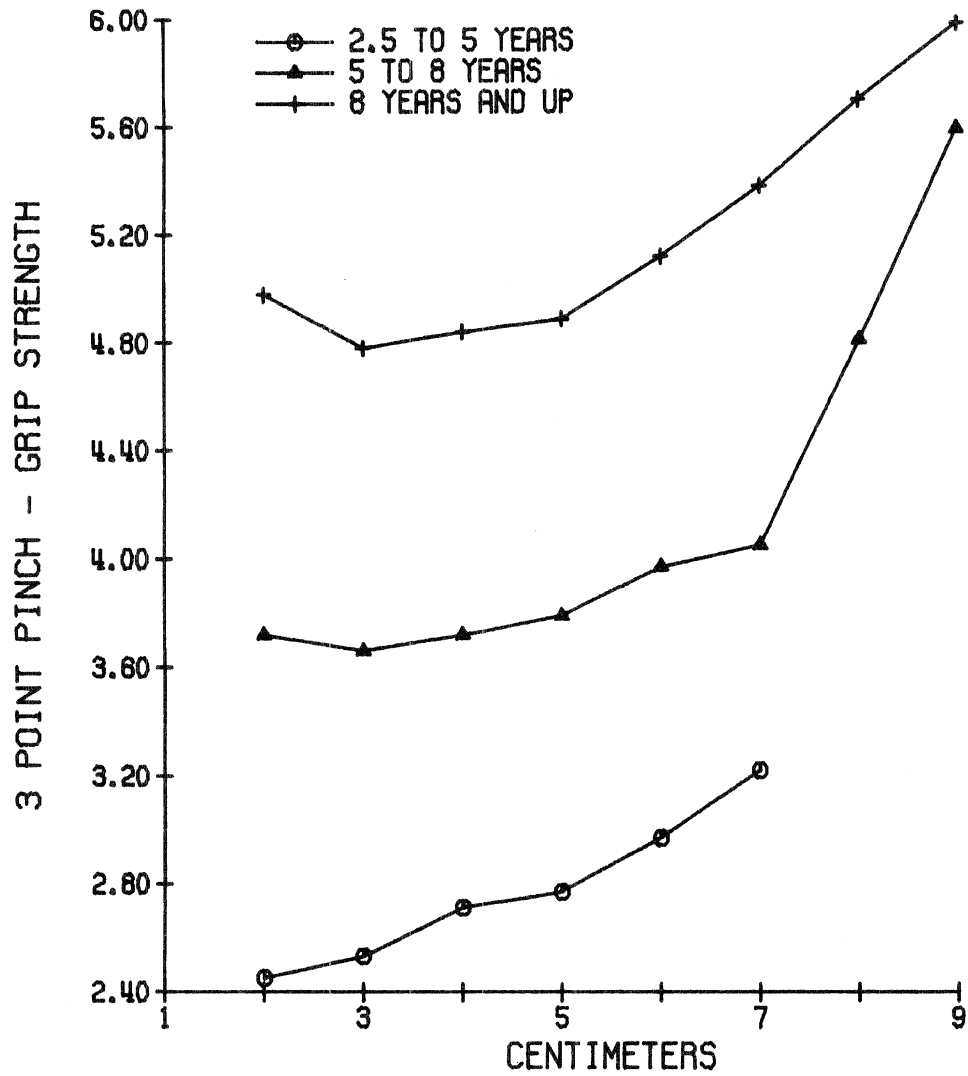
Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
6.5-7.5	1	0.6	**	0.6	**	0.6	**	0.6
7.5-8.5	3	0.7	0.4	0.4	**	0.6	**	1.1
8.5-9.5	9	0.8	0.4	0.1	**	0.8	**	1.4
9.5-10.5	18	0.7	0.4	0.1	**	0.7	**	1.3

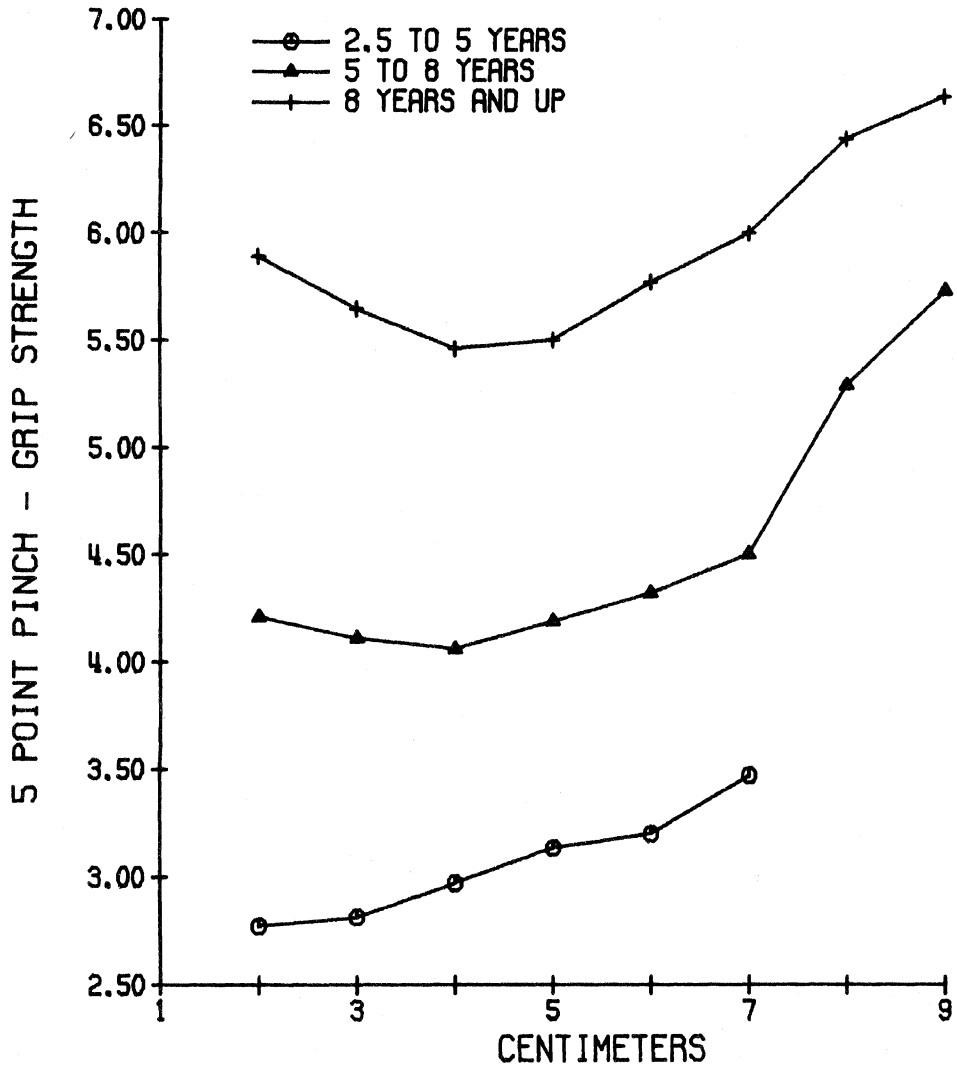


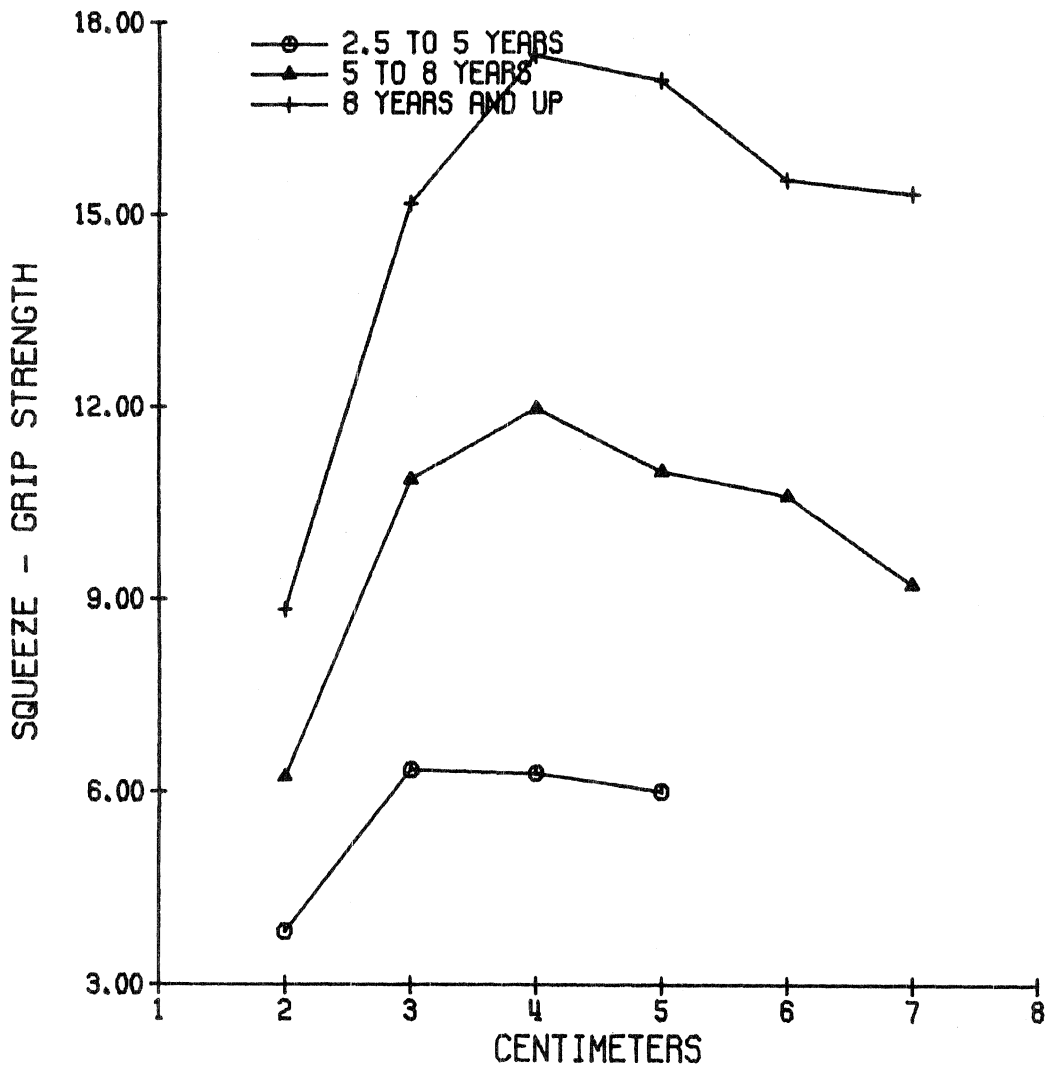
GRIP - SQUEEZE, angle at 7 cm (Degrees)  
(Males and Females)

Age (yrs)	N	Mean	s.d.	Min	5th	50th	95th	Max
6.5-7.5	1	1.5	**	1.5	**	1.5	**	1.5
7.5-8.5	3	0.8	2.9	-2.0	**	0.5	**	3.8
8.5-9.5	9	1.0	2.3	-1.7	**	0.2	**	4.3
9.5-10.5	18	1.9	2.8	-3.7	**	2.1	**	8.4









Grip Strength Statistics  
(2.5 - 3.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	5th	50th	95th	Max
3-Pt Pinch (2 cm-Force)	28	2.1	0.4	1.3	1.4	2.2	2.6	3.1
3-Pt Pinch (2 cm-LF,cm)	28	1.0	0.4	0.3	0.3	0.9	1.7	1.9
3-Pt Pinch (2 cm) Angle	28	-10.3	4.8	-17.1	-16.9	-10.9	-3.3	-1.4
3-Pt Pinch (3 cm-Force)	29	2.2	0.5	1.4	1.4	2.1	2.9	3.2
3-Pt Pinch (3 cm-LF,cm)	29	0.8	0.5	-0.7	-0.4	0.8	1.6	1.7
3-Pt Pinch (3 cm) Angle	29	-11.2	3.8	-18.2	-17.4	-11.9	-4.7	-3.5
3-Pt Pinch (4 cm-Force)	28	2.4	0.6	1.4	1.4	2.3	3.2	3.8
3-Pt Pinch (4 cm-LF,cm)	28	0.8	0.5	-0.4	-0.2	0.7	1.5	2.1
3-Pt Pinch (4 cm) Angle	28	-10.8	4.2	-17.4	-16.9	-11.0	-4.0	-3.6
3-Pt Pinch (5 cm-Force)	26	2.4	0.6	1.1	1.2	2.3	3.2	4.0
3-Pt Pinch (5 cm-LF,cm)	26	0.8	0.4	-0.1	-0.1	0.9	1.4	1.5
3-Pt Pinch (5 cm) Angle	26	-11.2	3.8	-18.4	-18.2	-11.9	-5.4	-4.6
3-Pt Pinch (6 cm-Force)	19	2.6	0.6	1.4	**	2.7	**	4.2
3-Pt Pinch (6 cm-LF,cm)	19	0.6	0.5	-0.4	**	0.5	**	1.7
3-Pt Pinch (6 cm) Angle	19	-9.2	2.9	-14.6	**	-9.4	**	-5.6
3-Pt Pinch (7 cm-Force)	1	4.3	**	4.3	**	4.3	**	4.3
3-Pt Pinch (7 cm-LF,cm)	1	1.2	**	1.2	**	1.2	**	1.2
3-Pt Pinch (7 cm) Angle	1	-7.5	**	-7.5	**	-7.5	**	-7.5
Squeeze (2 cm-Force)	31	3.1	1.0	1.0	1.4	2.9	4.6	5.3
Squeeze (2 cm-LF,cm)	31	1.2	0.6	0.1	0.2	1.0	2.2	2.3
Squeeze (2 cm) Angle	31	2.1	8.0	-16.1	-12.9	1.4	15.0	21.0
Squeeze (3 cm-Force)	31	5.0	1.6	2.7	2.8	4.6	7.8	9.6
Squeeze (3 cm-LF,cm)	31	0.8	0.4	0.1	0.1	0.8	1.4	1.8
Squeeze (3 cm) Angle	31	-0.7	4.0	-9.6	-9.4	-1.1	4.7	6.1
Squeeze (4 cm-Force)	31	4.9	1.8	2.1	2.4	4.5	8.3	9.3
Squeeze (4 cm-LF,cm)	31	0.9	0.4	0.1	0.2	0.9	1.4	1.9
Squeeze (4 cm) Angle	31	-2.1	4.9	-13.4	-13.3	-0.9	3.5	3.9
Squeeze (5 cm-Force)	8	4.3	0.8	3.0	**	3.8	**	5.5
Squeeze (5 cm-LF,cm)	8	0.8	0.5	0.2	**	0.8	**	1.4
Squeeze (5 cm) Angle	8	-3.5	5.7	-10.0	**	-6.6	**	8.3
5-Pt Pinch (2 cm-Force)	31	2.5	0.7	1.7	1.7	2.3	3.8	4.9
5-Pt Pinch (2 cm-LF,cm)	31	1.1	0.5	0.2	0.3	1.1	2.0	2.2
5-Pt Pinch (2 cm) Angle	31	-3.6	5.8	-16.3	-14.5	-4.1	3.2	17.3
5-Pt Pinch (3 cm-Force)	28	2.5	0.4	1.6	1.7	2.4	3.0	3.2
5-Pt Pinch (3 cm-LF,cm)	28	1.1	0.5	-0.2	-0.1	1.2	1.9	2.1
5-Pt Pinch (3 cm) Angle	28	-5.0	4.7	-16.0	-14.5	-5.4	3.2	7.0
5-Pt Pinch (4 cm-Force)	29	2.6	0.5	1.5	1.7	2.5	3.5	3.8
5-Pt Pinch (4 cm-LF,cm)	29	1.2	0.3	0.6	0.6	1.1	1.7	1.7
5-Pt Pinch (4 cm) Angle	29	-4.5	5.2	-12.6	-12.4	-4.4	2.4	11.9
5-Pt Pinch (5 cm-Force)	29	2.8	0.8	1.7	1.7	2.6	4.4	5.0
5-Pt Pinch (5 cm-LF,cm)	29	1.1	0.5	-1.0	-0.5	1.1	1.6	1.9
5-Pt Pinch (5 cm) Angle	29	-2.7	4.5	-10.7	-10.1	-3.2	4.8	9.5
5-Pt Pinch (6 cm-Force)	22	2.9	0.8	1.7	1.7	2.9	4.3	4.9
5-Pt Pinch (6 cm-LF,cm)	22	1.2	0.4	0.4	0.4	1.2	1.6	1.8
5-Pt Pinch (6 cm) Angle	22	-4.6	4.2	-13.6	-13.3	-4.3	1.9	4.6
5-Pt Pinch (7 cm-Force)	4	3.6	0.6	3.1	**	3.1	**	4.2
5-Pt Pinch (7 cm-LF,cm)	4	1.2	0.5	0.8	**	0.9	**	1.8
5-Pt Pinch (7 cm) Angle	4	-6.1	1.5	-7.8	**	-6.8	**	-4.5

Grip Strength Statistics  
(3.5 - 4.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
3-Pt Pinch (2 cm-Force)	44	2.6	0.5	1.5	1.6	2.6	3.3	3.7
3-Pt Pinch (2 cm-LF,cm)	44	1.1	0.4	0.2	0.4	1.1	1.7	1.7
3-Pt Pinch (2 cm) Angle	44	-8.2	4.2	-18.7	-17.4	-8.0	-2.6	0.0
3-Pt Pinch (3 cm-Force)	45	2.7	0.5	1.5	1.8	2.6	3.6	4.0
3-Pt Pinch (3 cm-LF,cm)	45	1.0	0.4	0.3	0.3	1.0	1.5	1.9
3-Pt Pinch (3 cm) Angle	45	-8.7	4.6	-20.7	-15.6	-8.7	-1.5	5.1
3-Pt Pinch (4 cm-Force)	45	2.9	0.6	1.8	1.8	2.7	4.0	4.3
3-Pt Pinch (4 cm-LF,cm)	45	0.9	0.4	-0.3	0.3	1.0	1.4	1.6
3-Pt Pinch (4 cm) Angle	45	-7.6	4.2	-13.5	-13.0	-7.9	-0.8	2.0
3-Pt Pinch (5 cm-Force)	43	2.9	0.7	1.5	1.6	2.9	4.0	4.6
3-Pt Pinch (5 cm-LF,cm)	43	0.9	0.4	-0.2	-0.1	0.9	1.6	1.9
3-Pt Pinch (5 cm) Angle	43	-6.7	3.7	-15.3	-12.6	-7.1	-0.2	2.3
3-Pt Pinch (6 cm-Force)	42	3.0	0.6	1.7	1.9	2.8	4.0	4.4
3-Pt Pinch (6 cm-LF,cm)	42	0.7	0.5	-0.1	-0.0	0.7	1.4	1.6
3-Pt Pinch (6 cm) Angle	42	-7.0	3.0	-15.8	-13.5	-7.1	-1.7	-0.6
3-Pt Pinch (7 cm-Force)	25	3.1	0.6	2.1	2.1	3.1	3.9	4.4
3-Pt Pinch (7 cm-LF,cm)	25	0.6	0.4	-0.1	-0.0	0.7	1.2	1.4
3-Pt Pinch (7 cm) Angle	25	-6.8	2.9	-12.5	-12.3	-7.2	-2.7	-2.6
3-Pt Pinch (8 cm-Force)	1	3.7	**	3.7	**	3.7	**	3.7
3-Pt Pinch (8 cm-LF,cm)	1	0.3	**	0.3	**	0.3	**	0.3
3-Pt Pinch (8 cm) Angle	1	-6.8	**	-6.8	**	-6.8	**	-6.8
Squeeze (2 cm-Force)	45	4.1	1.2	2.0	2.3	3.9	6.3	7.1
Squeeze (2 cm-LF,cm)	45	0.9	0.6	-0.4	-0.2	0.8	1.7	2.2
Squeeze (2 cm) Angle	45	5.6	6.9	-8.8	-5.1	5.2	14.3	28.3
Squeeze (3 cm-Force)	45	6.7	1.7	4.2	4.3	6.7	9.6	10.7
Squeeze (3 cm-LF,cm)	45	0.8	0.5	-0.1	0.0	0.7	1.6	2.0
Squeeze (3 cm) Angle	45	1.8	5.9	-11.4	-8.3	1.2	12.3	17.7
Squeeze (4 cm-Force)	45	6.7	1.9	3.2	3.8	6.8	9.6	11.2
Squeeze (4 cm-LF,cm)	45	0.8	0.4	0.0	0.1	0.8	1.4	2.0
Squeeze (4 cm) Angle	45	0.7	3.8	-8.0	-7.0	0.8	7.2	8.1
Squeeze (5 cm-Force)	31	6.0	1.8	2.4	2.8	6.1	8.8	9.8
Squeeze (5 cm-LF,cm)	31	1.0	0.4	0.2	0.2	0.9	1.6	1.7
Squeeze (5 cm) Angle	31	-1.2	3.5	-7.2	-6.5	-1.8	4.2	6.1
5-Pt Pinch (2 cm-Force)	45	2.9	0.5	2.0	2.0	2.9	3.7	4.2
5-Pt Pinch (2 cm-LF,cm)	45	1.2	0.5	-0.3	-0.0	1.2	1.9	2.2
5-Pt Pinch (2 cm) Angle	45	-2.2	4.1	-11.8	-10.6	-2.7	3.8	7.6
5-Pt Pinch (3 cm-Force)	45	2.9	0.6	1.7	1.9	2.8	3.9	4.8
5-Pt Pinch (3 cm-LF,cm)	45	1.1	0.5	0.1	0.2	1.1	1.8	2.2
5-Pt Pinch (3 cm) Angle	45	-2.7	3.8	-11.1	-9.4	-3.2	2.7	8.9
5-Pt Pinch (4 cm-Force)	45	3.1	0.8	1.5	2.0	3.1	4.5	5.7
5-Pt Pinch (4 cm-LF,cm)	45	1.2	0.5	0.2	0.3	1.3	1.9	2.2
5-Pt Pinch (4 cm) Angle	45	-2.9	4.6	-12.5	-9.8	-3.0	3.8	9.7
5-Pt Pinch (5 cm-Force)	45	3.2	0.9	1.6	1.9	3.0	5.1	5.6
5-Pt Pinch (5 cm-LF,cm)	45	1.1	0.5	-0.3	0.3	1.1	1.9	2.0
5-Pt Pinch (5 cm) Angle	45	-3.6	3.8	-10.5	-9.9	-3.7	1.5	6.8
5-Pt Pinch (6 cm-Force)	45	3.3	0.7	1.9	2.1	3.2	4.6	5.2
5-Pt Pinch (6 cm-LF,cm)	45	1.2	0.4	0.1	0.4	1.2	1.8	2.5
5-Pt Pinch (6 cm) Angle	45	-2.6	3.2	-8.4	-7.8	-3.2	3.7	5.1
5-Pt Pinch (7 cm-Force)	24	3.4	0.7	2.4	2.4	3.3	4.3	4.7
5-Pt Pinch (7 cm-LF,cm)	24	1.0	0.5	-0.0	0.1	1.1	1.6	1.8
5-Pt Pinch (7 cm) Angle	24	-2.5	3.4	-9.9	-9.4	-2.0	2.2	2.7
5-Pt Pinch (8 cm-Force)	1	3.8	**	3.8	**	3.8	**	3.8
5-Pt Pinch (8 cm-LF,cm)	1	1.1	**	1.1	**	1.1	**	1.1
5-Pt Pinch (8 cm) Angle	1	-2.1	**	-2.1	**	-2.1	**	-2.1

Grip Strength Statistics  
(4.5 - 5.5 years)

Measurement	N	Descriptive Statistics							
		Mean	s.d.	Min	5th	50th	95th	Max	
3-Pt Pinch (2 cm-Force)	44	3.1	0.6	1.9	2.1	3.0	4.2	4.3	
3-Pt Pinch (2 cm-LF,cm)	44	0.8	0.4	-0.5	0.0	0.9	1.2	1.6	
3-Pt Pinch (2 cm) Angle	44	-6.3	4.6	-15.4	-13.9	-7.2	2.2	3.4	
3-Pt Pinch (3 cm-Force)	44	3.0	0.7	1.9	2.0	2.9	4.2	5.3	
3-Pt Pinch (3 cm-LF,cm)	44	0.8	0.4	-0.1	0.0	0.8	1.3	1.5	
3-Pt Pinch (3 cm) Angle	44	-8.4	4.7	-19.3	-17.8	-8.5	-2.4	6.0	
3-Pt Pinch (4 cm-Force)	44	3.2	0.6	1.9	2.3	3.1	4.4	4.5	
3-Pt Pinch (4 cm-LF,cm)	44	0.8	0.4	-0.2	0.1	0.9	1.4	1.8	
3-Pt Pinch (4 cm) Angle	44	-7.8	4.1	-16.8	-15.6	-7.6	-1.0	2.8	
3-Pt Pinch (5 cm-Force)	44	3.4	0.7	1.7	1.9	3.2	4.6	5.1	
3-Pt Pinch (5 cm-LF,cm)	44	0.8	0.4	-0.1	0.1	0.8	1.4	1.7	
3-Pt Pinch (5 cm) Angle	44	-6.2	4.0	-17.9	-11.9	-6.0	-0.1	0.8	
3-Pt Pinch (6 cm-Force)	43	3.5	0.8	1.7	2.2	3.4	5.2	5.7	
3-Pt Pinch (6 cm-LF,cm)	43	0.8	0.4	0.2	0.2	0.7	1.4	1.9	
3-Pt Pinch (6 cm) Angle	43	-6.4	3.6	-18.5	-12.0	-6.0	-1.6	0.2	
3-Pt Pinch (7 cm-Force)	38	3.7	0.8	1.7	2.2	3.7	5.1	5.7	
3-Pt Pinch (7 cm-LF,cm)	38	0.7	0.4	0.0	0.2	0.6	1.4	1.9	
3-Pt Pinch (7 cm) Angle	38	-6.0	3.4	-12.9	-12.2	-6.1	-0.3	3.2	
3-Pt Pinch (8 cm-Force)	4	4.6	0.2	4.3	**	4.6	**	4.8	
3-Pt Pinch (8 cm-LF,cm)	4	0.4	0.2	0.1	**	0.3	**	0.6	
3-Pt Pinch (8 cm) Angle	4	-6.0	1.5	-7.1	**	-6.6	**	-3.8	
Squeeze (2 cm-Force)	44	5.0	1.4	2.4	2.5	4.9	7.1	8.2	
Squeeze (2 cm-LF,cm)	44	0.9	0.5	-0.3	0.1	0.9	1.8	2.3	
Squeeze (2 cm) Angle	44	6.9	7.7	-5.1	-3.4	5.7	21.9	31.2	
Squeeze (3 cm-Force)	44	9.1	2.3	4.1	5.2	8.8	13.0	13.4	
Squeeze (3 cm-LF,cm)	44	0.6	0.5	-0.3	-0.1	0.5	1.4	1.7	
Squeeze (3 cm) Angle	44	3.5	4.3	-3.2	-3.0	3.3	11.0	15.1	
Squeeze (4 cm-Force)	44	9.5	2.9	3.9	5.1	9.1	13.9	14.3	
Squeeze (4 cm-LF,cm)	44	0.6	0.3	0.1	0.2	0.6	1.0	1.1	
Squeeze (4 cm) Angle	44	1.2	4.2	-6.6	-6.2	1.4	7.0	7.3	
Squeeze (5 cm-Force)	41	8.5	2.5	3.8	4.1	8.4	12.5	14.0	
Squeeze (5 cm-LF,cm)	41	0.7	0.3	0.2	0.2	0.7	1.2	1.5	
Squeeze (5 cm) Angle	41	-0.3	3.4	-7.1	-6.4	-0.1	5.5	8.9	
Squeeze (6 cm-Force)	7	8.8	1.3	7.9	**	8.2	**	11.5	
Squeeze (6 cm-LF,cm)	7	1.0	0.4	0.4	**	0.8	**	1.6	
Squeeze (6 cm) Angle	7	0.2	3.2	-5.4	**	-0.3	**	5.1	
5-Pt Pinch (2 cm-Force)	44	3.6	0.9	2.3	2.4	3.5	5.1	5.6	
5-Pt Pinch (2 cm-LF,cm)	44	1.1	0.4	0.1	0.5	1.0	1.6	1.8	
5-Pt Pinch (2 cm) Angle	44	0.4	4.2	-8.2	-7.6	0.8	7.0	10.6	
5-Pt Pinch (3 cm-Force)	44	3.5	0.7	1.9	2.4	3.5	4.7	5.2	
5-Pt Pinch (3 cm-LF,cm)	44	1.0	0.4	0.3	0.5	1.0	1.7	1.9	
5-Pt Pinch (3 cm) Angle	44	-1.8	3.6	-13.0	-8.0	-1.6	2.6	6.4	
5-Pt Pinch (4 cm-Force)	44	3.5	0.8	1.9	2.2	3.4	5.0	5.4	
5-Pt Pinch (4 cm-LF,cm)	44	1.2	0.5	0.1	0.2	1.2	1.9	2.0	
5-Pt Pinch (4 cm) Angle	44	-1.7	3.8	-18.2	-5.8	-2.3	3.7	5.5	
5-Pt Pinch (5 cm-Force)	44	3.8	0.9	1.7	2.1	3.8	5.1	5.7	
5-Pt Pinch (5 cm-LF,cm)	44	1.2	0.4	0.0	0.2	1.2	1.8	2.1	
5-Pt Pinch (5 cm) Angle	44	-1.2	4.1	-18.3	-10.2	-0.9	3.9	7.4	
5-Pt Pinch (6 cm-Force)	43	3.8	0.9	2.2	2.2	3.7	5.1	6.9	
5-Pt Pinch (6 cm-LF,cm)	43	1.2	0.4	-0.3	0.6	1.2	1.8	2.2	
5-Pt Pinch (6 cm) Angle	43	-1.9	3.5	-10.9	-8.0	-1.4	2.9	5.2	
5-Pt Pinch (7 cm-Force)	38	4.0	1.0	2.1	2.5	3.9	5.5	6.5	
5-Pt Pinch (7 cm-LF,cm)	38	1.0	0.4	0.0	0.3	1.0	1.7	2.1	
5-Pt Pinch (7 cm) Angle	38	-1.6	3.2	-8.3	-7.3	-1.1	3.1	4.5	
5-Pt Pinch (8 cm-Force)	4	4.9	0.6	4.2	**	4.6	**	5.7	



Grip Strength Statistics  
(5.5 - 6.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	5th	50th	95th	Max
3-Pt Pinch (2 cm-Force)	49	3.6	0.8	1.9	2.1	3.7	4.7	6.2
3-Pt Pinch (2 cm-LF,cm)	48	0.8	0.4	0.1	0.2	0.8	1.5	1.7
3-Pt Pinch (2 cm) Angle	49	-5.0	4.4	-14.8	-12.8	-5.6	2.9	5.7
3-Pt Pinch (3 cm-Force)	49	3.5	0.7	2.4	2.5	3.5	4.6	6.0
3-Pt Pinch (3 cm-LF,cm)	49	0.7	0.5	-0.4	-0.2	0.7	1.5	1.8
3-Pt Pinch (3 cm) Angle	49	-5.9	3.6	-12.2	-11.1	-6.7	0.1	1.1
3-Pt Pinch (4 cm-Force)	49	3.5	0.8	2.3	2.4	3.2	5.0	6.0
3-Pt Pinch (4 cm-LF,cm)	49	0.7	0.3	0.1	0.2	0.7	1.3	1.6
3-Pt Pinch (4 cm) Angle	49	-6.5	3.6	-13.2	-12.1	-6.8	-0.2	2.2
3-Pt Pinch (5 cm-Force)	49	3.6	0.7	2.3	2.3	3.5	4.8	5.9
3-Pt Pinch (5 cm-LF,cm)	49	0.7	0.4	-0.3	-0.1	0.7	1.3	1.4
3-Pt Pinch (5 cm) Angle	49	-5.6	3.1	-15.3	-11.2	-5.3	-0.9	1.1
3-Pt Pinch (6 cm-Force)	49	3.8	0.7	2.1	2.9	3.7	4.8	5.5
3-Pt Pinch (6 cm-LF,cm)	49	0.7	0.3	-0.4	0.1	0.6	1.2	1.5
3-Pt Pinch (6 cm) Angle	49	-4.5	2.8	-10.5	-10.0	-4.9	0.3	3.2
3-Pt Pinch (7 cm-Force)	43	4.0	0.8	2.1	2.2	4.1	5.2	5.6
3-Pt Pinch (7 cm-LF,cm)	43	0.6	0.3	-0.1	0.2	0.5	1.3	1.5
3-Pt Pinch (7 cm) Angle	43	-4.0	2.8	-12.2	-8.6	-4.1	-0.3	2.6
3-Pt Pinch (8 cm-Force)	8	4.7	1.0	3.4	**	4.6	**	6.3
3-Pt Pinch (8 cm-LF,cm)	8	0.5	0.4	-0.2	**	0.5	**	0.8
3-Pt Pinch (8 cm) Angle	8	-3.4	3.5	-9.6	**	-2.7	**	2.4
3-Pt Pinch (9 cm-Force)	1	5.6	**	5.6	**	5.6	**	5.6
3-Pt Pinch (9 cm-LF,cm)	1	0.2	**	0.2	**	0.2	**	0.2
3-Pt Pinch (9 cm) Angle	1	-4.4	**	-4.4	**	-4.4	**	-4.4
Squeeze (2 cm-Force)	49	5.8	1.6	3.4	3.4	5.6	8.5	9.7
Squeeze (2 cm-LF,cm)	49	0.8	0.5	-0.3	0.0	0.8	1.5	2.0
Squeeze (2 cm) Angle	49	7.1	6.6	-11.5	-3.2	7.8	17.1	21.2
Squeeze (3 cm-Force)	49	10.1	2.2	4.5	5.6	10.3	13.4	13.9
Squeeze (3 cm-LF,cm)	49	0.6	0.4	-0.3	0.1	0.5	1.1	1.8
Squeeze (3 cm) Angle	49	4.0	3.3	-5.8	-1.1	3.7	9.0	11.9
Squeeze (4 cm-Force)	49	11.0	2.3	5.1	6.3	11.2	14.7	15.5
Squeeze (4 cm-LF,cm)	49	0.6	0.2	0.1	0.2	0.6	0.9	1.1
Squeeze (4 cm) Angle	49	2.4	3.6	-9.6	-2.3	2.3	7.4	11.9
Squeeze (5 cm-Force)	47	9.9	2.5	5.4	5.6	9.4	13.2	17.3
Squeeze (5 cm-LF,cm)	47	0.7	0.2	0.2	0.2	0.7	1.0	1.5
Squeeze (5 cm) Angle	47	1.1	3.3	-5.8	-4.9	1.2	6.0	7.2
Squeeze (6 cm-Force)	10	8.9	2.6	4.1	**	7.8	**	12.5
Squeeze (6 cm-LF,cm)	10	0.9	0.3	0.4	**	0.9	**	1.6
Squeeze (6 cm) Angle	10	-1.0	1.1	-3.0	**	-1.2	**	0.1
5-Pt Pinch (2 cm-Force)	49	4.0	0.8	2.0	2.6	4.0	5.5	6.3
5-Pt Pinch (2 cm-LF,cm)	49	1.0	0.4	0.1	0.4	1.0	1.6	2.3
5-Pt Pinch (2 cm) Angle	49	1.2	3.5	-5.8	-5.0	1.2	6.6	11.7
5-Pt Pinch (3 cm-Force)	49	3.8	0.8	2.5	2.7	3.7	5.0	6.4
5-Pt Pinch (3 cm-LF,cm)	49	0.9	0.4	-0.0	0.2	1.0	1.5	1.8
5-Pt Pinch (3 cm) Angle	49	-1.1	3.2	-13.4	-5.8	-1.3	3.5	5.4
5-Pt Pinch (4 cm-Force)	49	3.9	0.7	2.3	2.7	3.9	4.7	6.4
5-Pt Pinch (4 cm-LF,cm)	49	1.0	0.5	-0.2	0.2	1.0	1.7	1.8
5-Pt Pinch (4 cm) Angle	49	-1.6	4.0	-8.8	-8.1	-1.9	4.9	9.2
5-Pt Pinch (5 cm-Force)	49	3.9	0.8	2.3	2.7	3.8	5.1	6.3
5-Pt Pinch (5 cm-LF,cm)	49	1.2	0.4	0.3	0.4	1.2	1.8	2.0
5-Pt Pinch (5 cm) Angle	49	-0.6	4.4	-11.8	-9.8	0.0	5.2	7.6
5-Pt Pinch (6 cm-Force)	49	4.0	0.8	2.6	2.9	3.9	5.4	6.2
5-Pt Pinch (6 cm-LF,cm)	49	1.2	0.3	0.4	0.5	1.1	1.7	1.9
5-Pt Pinch (6 cm) Angle	49	0.0	3.5	-9.2	-7.5	0.1	5.7	9.2
5-Pt Pinch (7 cm-Force)	43	4.3	0.9	3.0	3.0	4.3	5.6	6.7

Grip Strength Statistics  
(6.5 - 7.5 years)

Measurement	N	Descriptive Statistics							
		Mean	s.d.	Min	5th	50th	95th	Max	
3-Pt Pinch (2 cm-Force)	46	4.0	0.7	2.2	2.8	4.0	4.9	5.5	
3-Pt Pinch (2 cm-LF,cm)	46	0.8	0.4	0.1	0.2	0.8	1.3	1.9	
3-Pt Pinch (2 cm) Angle	46	-4.4	3.0	-10.5	-10.3	-5.2	0.7	1.6	
3-Pt Pinch (3 cm-Force)	46	3.9	0.6	2.4	2.9	3.9	5.0	5.3	
3-Pt Pinch (3 cm-LF,cm)	46	0.8	0.4	0.0	0.1	0.7	1.3	1.9	
3-Pt Pinch (3 cm) Angle	46	-5.5	4.2	-18.3	-10.3	-6.4	1.5	9.0	
3-Pt Pinch (4 cm-Force)	46	3.8	0.7	2.3	2.5	3.8	4.9	5.4	
3-Pt Pinch (4 cm-LF,cm)	46	0.7	0.4	-0.3	-0.1	0.7	1.4	1.6	
3-Pt Pinch (4 cm) Angle	46	-5.9	3.9	-15.7	-13.3	-6.9	0.3	2.6	
3-Pt Pinch (5 cm-Force)	46	4.0	0.7	2.7	2.9	4.1	4.9	5.6	
3-Pt Pinch (5 cm-LF,cm)	46	0.8	0.4	0.2	0.2	0.8	1.3	1.8	
3-Pt Pinch (5 cm) Angle	46	-4.8	3.3	-11.0	-10.8	-4.9	1.0	1.2	
3-Pt Pinch (6 cm-Force)	46	4.3	0.8	2.4	3.0	4.3	5.7	5.8	
3-Pt Pinch (6 cm-LF,cm)	46	0.8	0.4	0.0	0.2	0.7	1.4	2.2	
3-Pt Pinch (6 cm) Angle	46	-4.1	3.3	-11.9	-8.7	-4.2	-0.1	8.6	
3-Pt Pinch (7 cm-Force)	46	4.2	0.8	2.7	3.0	4.2	5.7	6.3	
3-Pt Pinch (7 cm-LF,cm)	46	0.7	0.4	-0.3	0.0	0.7	1.2	1.3	
3-Pt Pinch (7 cm) Angle	46	-4.6	2.7	-10.6	-9.9	-4.6	-0.7	0.9	
3-Pt Pinch (8 cm-Force)	20	4.7	1.2	2.5	**	4.7	**	7.9	
3-Pt Pinch (8 cm-LF,cm)	20	0.7	0.3	0.1	**	0.7	**	1.2	
3-Pt Pinch (8 cm) Angle	20	-5.0	3.1	-12.0	**	-4.3	**	-0.9	
3-Pt Pinch (9 cm-Force)	1	5.2	**	5.2	**	5.2	**	5.2	
3-Pt Pinch (9 cm-LF,cm)	1	0.5	**	0.5	**	0.5	**	0.5	
3-Pt Pinch (9 cm) Angle	1	-5.0	**	-5.0	**	-5.0	**	-5.0	
Squeeze (2 cm-Force)	46	6.7	2.0	2.9	4.0	6.4	10.2	11.4	
Squeeze (2 cm-LF,cm)	46	0.8	0.4	0.1	0.2	0.8	1.7	2.0	
Squeeze (2 cm) Angle	46	6.9	5.9	-12.8	-2.7	6.5	15.5	17.3	
Squeeze (3 cm-Force)	46	11.7	2.7	7.3	7.7	11.1	15.8	18.4	
Squeeze (3 cm-LF,cm)	46	0.6	0.3	-0.0	0.1	0.5	1.1	1.6	
Squeeze (3 cm) Angle	46	4.4	3.6	-3.0	-1.0	3.7	9.1	16.3	
Squeeze (4 cm-Force)	46	13.1	2.6	7.3	8.6	13.1	17.0	18.3	
Squeeze (4 cm-LF,cm)	46	0.6	0.3	-0.0	0.0	0.6	0.9	1.3	
Squeeze (4 cm) Angle	46	3.6	3.4	-3.3	-2.5	3.2	9.2	12.2	
Squeeze (5 cm-Force)	46	12.0	2.7	6.0	7.1	12.0	16.4	16.9	
Squeeze (5 cm-LF,cm)	46	0.7	0.3	0.1	0.2	0.6	1.2	1.6	
Squeeze (5 cm) Angle	46	2.2	2.9	-5.1	-2.2	1.9	6.9	7.8	
Squeeze (6 cm-Force)	28	10.7	2.0	6.8	7.1	10.9	13.7	14.5	
Squeeze (6 cm-LF,cm)	28	0.8	0.3	0.0	0.1	0.8	1.3	1.4	
Squeeze (6 cm) Angle	28	1.1	5.0	-9.5	-7.3	0.1	9.2	18.5	
Squeeze (7 cm-Force)	1	9.2	**	9.2	**	9.2	**	9.2	
Squeeze (7 cm-LF,cm)	1	0.6	**	0.6	**	0.6	**	0.6	
Squeeze (7 cm) Angle	1	1.5	**	1.5	**	1.5	**	1.5	
5-Pt Pinch (2 cm-Force)	46	4.4	1.0	2.3	2.8	4.4	6.0	6.8	
5-Pt Pinch (2 cm-LF,cm)	46	1.1	0.4	0.3	0.4	1.1	1.7	2.0	
5-Pt Pinch (2 cm) Angle	46	1.5	3.4	-7.3	-4.5	1.2	7.0	7.9	
5-Pt Pinch (3 cm-Force)	46	4.4	0.9	2.4	2.8	4.5	5.8	6.0	
5-Pt Pinch (3 cm-LF,cm)	46	1.0	0.4	0.2	0.3	0.9	1.6	1.9	
5-Pt Pinch (3 cm) Angle	46	-0.9	3.7	-10.3	-6.8	-1.4	4.6	6.4	
5-Pt Pinch (4 cm-Force)	46	4.3	0.8	2.5	2.6	4.2	5.6	5.7	
5-Pt Pinch (4 cm-LF,cm)	46	1.1	0.4	0.2	0.3	1.1	1.8	2.1	
5-Pt Pinch (4 cm) Angle	46	-1.1	5.1	-10.0	-9.3	-1.6	7.4	13.3	
5-Pt Pinch (5 cm-Force)	46	4.4	0.8	2.9	3.0	4.2	5.8	6.7	
5-Pt Pinch (5 cm-LF,cm)	46	1.2	0.4	0.2	0.5	1.1	1.9	2.3	
5-Pt Pinch (5 cm) Angle	46	-0.5	4.3	-9.7	-8.3	-0.9	6.7	8.2	
5-Pt Pinch (6 cm-Force)	46	4.6	0.9	2.5	3.1	4.5	6.0	6.5	

Grip Strength Statistics  
(7.5 - 8.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
3-Pt Pinch (2 cm-Force)	52	4.4	1.0	2.5	3.0	4.3	6.4	6.7
3-Pt Pinch (2 cm-LF,cm)	52	0.6	0.3	-0.2	0.1	0.6	1.2	1.6
3-Pt Pinch (2 cm) Angle	52	-3.8	3.1	-11.3	-8.3	-4.3	1.2	4.4
3-Pt Pinch (3 cm-Force)	52	4.4	0.9	2.7	2.9	4.2	5.8	6.2
3-Pt Pinch (3 cm-LF,cm)	52	0.6	0.3	0.1	0.2	0.6	1.1	1.2
3-Pt Pinch (3 cm) Angle	52	-5.2	3.3	-10.9	-9.8	-5.6	0.0	1.9
3-Pt Pinch (4 cm-Force)	52	4.4	0.9	2.8	3.0	4.4	6.0	6.0
3-Pt Pinch (4 cm-LF,cm)	52	0.6	0.3	-0.1	-0.0	0.6	1.1	1.5
3-Pt Pinch (4 cm) Angle	52	-4.5	3.9	-12.6	-11.4	-4.6	1.3	3.3
3-Pt Pinch (5 cm-Force)	52	4.4	0.8	3.0	3.1	4.4	5.7	6.0
3-Pt Pinch (5 cm-LF,cm)	52	0.7	0.4	-0.4	-0.1	0.7	1.3	2.0
3-Pt Pinch (5 cm) Angle	52	-3.4	3.9	-12.0	-11.9	-3.4	2.8	5.4
3-Pt Pinch (6 cm-Force)	52	4.5	0.9	2.7	3.1	4.4	6.0	6.9
3-Pt Pinch (6 cm-LF,cm)	52	0.7	0.4	-0.0	0.1	0.6	1.3	1.7
3-Pt Pinch (6 cm) Angle	52	-2.9	2.9	-11.8	-7.9	-2.7	1.8	3.6
3-Pt Pinch (7 cm-Force)	52	4.5	0.8	2.9	3.2	4.5	6.0	6.7
3-Pt Pinch (7 cm-LF,cm)	52	0.7	0.4	0.0	0.1	0.6	1.3	1.6
3-Pt Pinch (7 cm) Angle	52	-3.2	2.4	-8.5	-7.7	-3.1	0.4	3.2
3-Pt Pinch (8 cm-Force)	29	5.3	1.1	3.3	3.4	5.5	6.9	7.2
3-Pt Pinch (8 cm-LF,cm)	29	0.6	0.3	-0.1	0.0	0.5	1.1	1.2
3-Pt Pinch (8 cm) Angle	29	-3.3	2.7	-10.9	-10.4	-3.2	-0.3	2.5
3-Pt Pinch (9 cm-Force)	5	6.0	1.0	4.3	**	6.0	**	7.1
3-Pt Pinch (9 cm-LF,cm)	5	0.6	0.2	0.3	**	0.6	**	1.0
3-Pt Pinch (9 cm) Angle	5	-2.2	2.5	-4.5	**	-3.2	**	1.9
Squeeze (2 cm-Force)	52	7.6	2.2	4.1	4.6	7.2	11.6	13.1
Squeeze (2 cm-LF,cm)	52	0.7	0.4	-0.2	-0.0	0.6	1.3	1.8
Squeeze (2 cm) Angle	52	7.9	6.1	-3.8	-3.1	7.5	18.4	20.8
Squeeze (3 cm-Force)	52	13.2	3.0	6.8	8.6	12.6	18.2	20.4
Squeeze (3 cm-LF,cm)	52	0.5	0.3	-0.2	-0.2	0.5	0.9	1.1
Squeeze (3 cm) Angle	52	4.3	3.1	-1.9	-0.8	4.0	9.6	12.8
Squeeze (4 cm-Force)	52	15.0	2.8	9.9	10.9	14.7	20.0	21.8
Squeeze (4 cm-LF,cm)	52	0.5	0.2	0.0	0.1	0.5	0.9	1.2
Squeeze (4 cm) Angle	52	3.6	2.2	-1.2	0.7	3.0	7.6	9.6
Squeeze (5 cm-Force)	52	14.2	2.8	8.0	9.3	14.4	19.4	20.6
Squeeze (5 cm-LF,cm)	52	0.6	0.3	0.1	0.1	0.6	1.0	1.7
Squeeze (5 cm) Angle	52	2.4	2.4	-1.9	-0.7	1.8	6.6	8.6
Squeeze (6 cm-Force)	40	12.8	3.0	5.7	6.5	13.0	16.9	19.0
Squeeze (6 cm-LF,cm)	40	0.7	0.3	-0.1	0.2	0.7	1.2	1.7
Squeeze (6 cm) Angle	40	1.6	2.6	-3.3	-2.4	1.1	4.7	9.5
Squeeze (7 cm-Force)	3	12.4	3.4	11.6	**	11.7	**	13.9
Squeeze (7 cm-LF,cm)	3	0.7	0.1	0.4	**	0.6	**	1.1
Squeeze (7 cm) Angle	3	0.8	8.4	-2.0	**	0.5	**	3.8
5-Pt Pinch (2 cm-Force)	52	5.0	0.9	3.3	3.5	4.8	6.5	8.3
5-Pt Pinch (2 cm-LF,cm)	52	1.0	0.3	0.3	0.5	0.9	1.4	1.6
5-Pt Pinch (2 cm) Angle	52	2.4	3.0	-5.1	-3.8	2.8	6.7	10.0
5-Pt Pinch (3 cm-Force)	52	5.0	0.9	3.2	3.7	4.9	6.3	7.3
5-Pt Pinch (3 cm-LF,cm)	52	0.9	0.3	0.3	0.4	0.8	1.5	1.7
5-Pt Pinch (3 cm) Angle	52	-0.0	3.0	-9.4	-5.7	0.5	3.7	5.3
5-Pt Pinch (4 cm-Force)	52	4.8	0.9	3.0	3.2	4.7	6.2	6.8
5-Pt Pinch (4 cm-LF,cm)	52	1.0	0.5	-0.1	-0.0	1.0	1.7	2.4
5-Pt Pinch (4 cm) Angle	52	-0.4	3.2	-9.1	-5.8	-0.1	3.4	8.2
5-Pt Pinch (5 cm-Force)	52	4.9	0.9	3.2	3.3	4.7	6.5	6.7
5-Pt Pinch (5 cm-LF,cm)	52	1.1	0.5	-0.1	0.1	1.0	1.9	2.3
5-Pt Pinch (5 cm) Angle	52	0.1	4.2	-10.7	-8.3	-0.6	5.7	6.6
5-Pt Pinch (6 cm-Force)	52	5.0	1.0	3.2	3.4	4.9	6.5	8.0

Grip Strength Statistics  
(8.5 - 9.5 years)

Measurement	N	Descriptive Statistics						
		Mean	s.d.	Min	5th	50th	95th	Max
3-Pt Pinch (2 cm-Force)	42	5.0	0.9	2.8	3.2	5.0	6.3	7.3
3-Pt Pinch (2 cm-LF,cm)	42	0.7	0.4	-0.0	0.1	0.6	1.1	2.2
3-Pt Pinch (2 cm) Angle	42	-2.2	3.7	-9.5	-8.3	-2.8	2.6	5.1
3-Pt Pinch (3 cm-Force)	42	4.7	0.7	2.9	3.1	4.7	5.7	6.0
3-Pt Pinch (3 cm-LF,cm)	42	0.7	0.4	0.1	0.1	0.7	1.2	1.8
3-Pt Pinch (3 cm) Angle	42	-4.2	3.6	-11.1	-10.0	-3.8	2.3	3.7
3-Pt Pinch (4 cm-Force)	42	4.8	0.9	3.3	3.4	4.7	6.1	7.0
3-Pt Pinch (4 cm-LF,cm)	42	0.7	0.4	-0.0	-0.0	0.6	1.4	1.6
3-Pt Pinch (4 cm) Angle	42	-4.2	3.7	-12.9	-10.3	-3.8	0.5	2.2
3-Pt Pinch (5 cm-Force)	42	4.8	1.1	3.2	3.4	4.7	6.7	8.3
3-Pt Pinch (5 cm-LF,cm)	42	0.7	0.3	-0.1	0.2	0.7	1.3	1.4
3-Pt Pinch (5 cm) Angle	42	-3.3	3.6	-13.4	-9.2	-3.5	3.7	4.2
3-Pt Pinch (6 cm-Force)	42	5.0	1.1	3.1	3.4	4.9	6.7	8.1
3-Pt Pinch (6 cm-LF,cm)	42	0.8	0.3	0.1	0.2	0.7	1.3	1.4
3-Pt Pinch (6 cm) Angle	42	-3.0	2.6	-8.5	-7.1	-3.1	0.9	4.8
3-Pt Pinch (7 cm-Force)	41	5.4	1.2	3.2	3.7	5.2	7.3	8.5
3-Pt Pinch (7 cm-LF,cm)	41	0.7	0.3	0.1	0.2	0.7	1.2	1.4
3-Pt Pinch (7 cm) Angle	41	-2.1	2.7	-7.8	-6.0	-2.2	1.9	4.1
3-Pt Pinch (8 cm-Force)	34	5.5	1.1	3.1	3.2	5.8	7.0	7.4
3-Pt Pinch (8 cm-LF,cm)	34	0.7	0.4	-0.0	0.0	0.5	1.3	1.8
3-Pt Pinch (8 cm) Angle	34	-2.6	1.9	-6.5	-6.1	-2.7	0.2	1.2
3-Pt Pinch (9 cm-Force)	10	5.4	1.2	3.4	**	5.3	**	7.1
3-Pt Pinch (9 cm-LF,cm)	10	0.3	0.2	0.1	**	0.3	**	0.7
3-Pt Pinch (9 cm) Angle	10	-2.5	1.7	-5.4	**	-2.3	**	-0.5
Squeeze (2 cm-Force)	42	8.9	2.8	3.8	4.2	8.4	14.1	15.4
Squeeze (2 cm-LF,cm)	42	0.7	0.5	-0.4	0.1	0.6	1.4	2.3
Squeeze (2 cm) Angle	42	9.1	5.5	-10.4	-1.7	9.9	15.8	20.0
Squeeze (3 cm-Force)	42	15.3	3.2	9.1	9.9	15.4	20.5	23.2
Squeeze (3 cm-LF,cm)	42	0.5	0.3	-0.1	0.1	0.5	0.9	1.3
Squeeze (3 cm) Angle	42	5.3	2.8	-1.4	0.3	5.2	8.9	14.0
Squeeze (4 cm-Force)	42	17.2	3.3	11.4	12.2	16.5	22.4	25.6
Squeeze (4 cm-LF,cm)	42	0.6	0.2	-0.0	0.2	0.6	0.9	1.0
Squeeze (4 cm) Angle	42	4.6	3.1	-1.4	0.3	4.3	9.3	13.4
Squeeze (5 cm-Force)	42	16.3	3.2	10.6	11.0	16.0	22.4	24.3
Squeeze (5 cm-LF,cm)	42	0.6	0.2	0.2	0.2	0.6	1.0	1.1
Squeeze (5 cm) Angle	42	3.4	2.7	-1.9	-1.8	3.7	7.1	9.2
Squeeze (6 cm-Force)	39	15.2	3.0	10.6	10.6	14.8	20.9	21.5
Squeeze (6 cm-LF,cm)	39	0.6	0.3	0.0	0.1	0.6	1.0	1.3
Squeeze (6 cm) Angle	39	2.8	2.5	-2.9	-2.3	3.0	6.1	8.7
Squeeze (7 cm-Force)	9	13.3	2.0	10.6	**	12.9	**	16.3
Squeeze (7 cm-LF,cm)	9	0.8	0.4	0.1	**	0.8	**	1.4
Squeeze (7 cm) Angle	9	1.0	2.3	-1.7	**	0.2	**	4.3
5-Pt Pinch (2 cm-Force)	42	5.8	1.2	3.7	3.8	5.7	8.0	8.9
5-Pt Pinch (2 cm-LF,cm)	42	1.0	0.3	0.5	0.6	1.0	1.6	1.6
5-Pt Pinch (2 cm) Angle	42	3.1	3.8	-5.5	-5.1	3.3	9.0	10.1
5-Pt Pinch (3 cm-Force)	42	5.6	1.1	3.4	3.8	5.6	7.1	8.3
5-Pt Pinch (3 cm-LF,cm)	42	1.0	0.4	0.2	0.2	0.9	1.6	2.0
5-Pt Pinch (3 cm) Angle	42	0.9	3.3	-5.6	-4.9	0.9	6.4	7.8
5-Pt Pinch (4 cm-Force)	42	5.4	1.0	3.6	3.6	5.1	7.2	7.8
5-Pt Pinch (4 cm-LF,cm)	42	1.1	0.5	0.0	0.2	0.9	2.0	2.4
5-Pt Pinch (4 cm) Angle	42	0.8	3.6	-6.8	-4.7	0.6	5.4	10.4
5-Pt Pinch (5 cm-Force)	42	5.5	1.1	3.6	3.7	5.3	7.1	8.0
5-Pt Pinch (5 cm-LF,cm)	42	1.3	0.5	0.2	0.3	1.3	2.0	2.3
5-Pt Pinch (5 cm) Angle	42	1.9	4.5	-9.7	-5.6	1.5	9.8	10.5
5-Pt Pinch (6 cm-Force)	42	5.9	1.3	3.7	4.0	5.8	8.1	9.5

Grip Strength Statistics  
(9.5 - 10.5 years)

Measurement	N	Descriptive Statistics							
		Mean	s.d.	Min	5th	50th	95th	Max	
3-Pt Pinch (2 cm-Force)	44	5.2	1.0	3.4	3.7	5.1	6.7	9.7	
3-Pt Pinch (2 cm-LF,cm)	44	0.6	0.3	-0.0	0.0	0.7	1.0	1.2	
3-Pt Pinch (2 cm) Angle	44	-2.2	3.3	-8.1	-7.2	-2.5	2.1	4.5	
3-Pt Pinch (3 cm-Force)	45	5.0	0.9	3.6	4.0	4.8	6.6	8.4	
3-Pt Pinch (3 cm-LF,cm)	45	0.5	0.3	0.1	0.1	0.5	1.1	1.4	
3-Pt Pinch (3 cm) Angle	45	-3.6	3.0	-10.6	-9.6	-3.6	1.5	3.1	
3-Pt Pinch (4 cm-Force)	45	5.2	1.1	3.6	3.9	5.0	7.5	8.2	
3-Pt Pinch (4 cm-LF,cm)	45	0.5	0.3	-0.2	0.1	0.5	1.1	1.2	
3-Pt Pinch (4 cm) Angle	45	-3.2	3.5	-11.6	-8.5	-3.6	3.6	5.8	
3-Pt Pinch (5 cm-Force)	45	5.3	1.0	3.3	3.5	5.1	7.3	7.6	
3-Pt Pinch (5 cm-LF,cm)	45	0.6	0.3	0.1	0.1	0.7	1.1	1.2	
3-Pt Pinch (5 cm) Angle	45	-2.7	3.1	-9.2	-9.0	-3.5	1.8	5.9	
3-Pt Pinch (6 cm-Force)	45	5.5	1.0	3.4	3.9	5.3	7.0	7.6	
3-Pt Pinch (6 cm-LF,cm)	45	0.7	0.3	0.0	0.2	0.7	1.1	1.2	
3-Pt Pinch (6 cm) Angle	45	-1.9	2.9	-9.3	-7.2	-1.5	2.9	5.1	
3-Pt Pinch (7 cm-Force)	45	5.8	1.1	4.1	4.2	5.6	7.9	8.6	
3-Pt Pinch (7 cm-LF,cm)	45	0.7	0.3	-0.1	0.1	0.7	1.1	1.7	
3-Pt Pinch (7 cm) Angle	45	-1.7	2.7	-9.3	-6.4	-1.8	2.3	3.3	
3-Pt Pinch (8 cm-Force)	43	6.0	1.1	4.4	4.5	5.7	8.1	8.8	
3-Pt Pinch (8 cm-LF,cm)	43	0.6	0.3	-0.0	0.1	0.6	1.0	1.2	
3-Pt Pinch (8 cm) Angle	43	-1.8	2.4	-8.4	-4.7	-2.4	1.4	6.7	
3-Pt Pinch (9 cm-Force)	25	6.2	0.8	4.3	4.5	6.1	7.4	7.9	
3-Pt Pinch (9 cm-LF,cm)	25	0.5	0.3	0.1	0.1	0.4	0.9	1.1	
3-Pt Pinch (9 cm) Angle	25	-2.5	2.3	-6.7	-6.5	-2.5	0.5	3.5	
Squeeze (2 cm-Force)	45	9.7	3.0	4.2	5.0	9.7	14.0	17.8	
Squeeze (2 cm-LF,cm)	45	0.6	0.4	-0.1	-0.0	0.5	1.2	1.6	
Squeeze (2 cm) Angle	45	9.9	4.2	-2.7	1.8	9.6	16.4	21.1	
Squeeze (3 cm-Force)	45	16.1	3.1	10.0	10.3	16.5	21.1	21.8	
Squeeze (3 cm-LF,cm)	45	0.5	0.3	-0.0	0.0	0.5	0.9	1.0	
Squeeze (3 cm) Angle	45	6.3	2.6	1.5	1.7	6.3	9.8	10.9	
Squeeze (4 cm-Force)	45	19.1	3.5	11.0	13.1	19.0	25.0	27.9	
Squeeze (4 cm-LF,cm)	45	0.5	0.2	0.1	0.2	0.5	1.1	1.2	
Squeeze (4 cm) Angle	45	4.4	2.3	1.0	1.1	3.9	8.3	11.4	
Squeeze (5 cm-Force)	45	19.5	2.7	15.0	15.2	19.2	23.9	27.8	
Squeeze (5 cm-LF,cm)	45	0.6	0.2	0.1	0.2	0.6	0.9	1.0	
Squeeze (5 cm) Angle	45	4.0	1.9	-0.9	0.6	4.1	7.0	9.0	
Squeeze (6 cm-Force)	44	17.2	3.8	10.1	10.6	17.2	23.3	26.1	
Squeeze (6 cm-LF,cm)	44	0.6	0.3	-0.0	0.1	0.6	1.3	1.5	
Squeeze (6 cm) Angle	44	2.4	2.8	-1.6	-1.5	1.7	7.3	9.0	
Squeeze (7 cm-Force)	18	16.8	3.6	10.5	**	17.2	**	24.6	
Squeeze (7 cm-LF,cm)	18	0.7	0.4	0.1	**	0.7	**	1.3	
Squeeze (7 cm) Angle	18	1.9	2.8	-3.7	**	2.1	**	8.4	
5-Pt Pinch (2 cm-Force)	45	6.5	1.4	4.1	4.7	6.3	8.2	11.8	
5-Pt Pinch (2 cm-LF,cm)	45	1.0	0.3	0.4	0.4	1.0	1.4	1.5	
5-Pt Pinch (2 cm) Angle	45	4.0	2.9	-2.4	-0.5	4.0	8.8	10.6	
5-Pt Pinch (3 cm-Force)	45	6.1	1.3	4.1	4.4	5.8	7.6	10.9	
5-Pt Pinch (3 cm-LF,cm)	45	0.9	0.4	0.1	0.3	0.9	1.4	1.7	
5-Pt Pinch (3 cm) Angle	45	1.3	3.0	-6.3	-3.5	1.4	5.5	7.9	
5-Pt Pinch (4 cm-Force)	45	5.9	1.2	3.9	4.0	5.7	7.7	10.3	
5-Pt Pinch (4 cm-LF,cm)	45	1.0	0.4	0.1	0.3	1.0	1.5	1.9	
5-Pt Pinch (4 cm) Angle	45	1.7	3.7	-4.8	-4.2	1.7	8.2	10.1	
5-Pt Pinch (5 cm-Force)	45	5.9	0.9	3.9	4.8	5.9	7.3	8.6	
5-Pt Pinch (5 cm-LF,cm)	45	1.1	0.5	0.1	0.3	1.1	1.8	2.3	
5-Pt Pinch (5 cm) Angle	45	1.8	3.5	-5.1	-4.2	1.5	7.0	8.9	
5-Pt Pinch (6 cm-Force)	45	6.1	1.2	3.6	4.6	5.7	8.3	8.8	

ZERO ORDER CORRELATIONS

3 Point Pinch

	Height	Weight	Finger Linkage	Cervical Linkage	Hand Length	Hand Breadth	Grip Outside Diameter
2 cm	.8074	.7796	.7355	.6122	.7861	.7558	.7764
3 cm	.7968	.7751	.7260	.6278	.7717	.7568	.7692
4 cm	.7460	.7397	.6772	.5844	.7219	.7109	.7712
5 cm	.7291	.7184	.6480	.5509	.6881	.7024	.6862
6 cm	.7415	.7438	.6480	.5855	.6870	.7060	.6674
7 cm	.6372	.6531	.5470	.4244	.5848	.6201	.5738
8 cm	.3734	.3958	.2972	.1909	.3654	.4646	.3804
9 cm	.2106	.2314	.2498	.2234	.1964	.1351	.2919

ZERO ORDER CORRELATIONS

	Height	Weight	Finger Linkage	Cervical Linkage	Hand Length	Hand Breadth	Grip Outside Diameter
Squeeze							
2 cm	.6846	.6240	.5752	.5057	.6311	.6278	.6136
3 cm	.7809	.7271	.6950	.6258	.7396	.7578	.7323
4 cm	.8665	.8188	.7967	.6765	.8359	.8367	.8205
5 cm	.8609	.8107	.7647	.6425	.8211	.8187	.8030
6 cm	.7286	.6780	.5953	.4609	.7047	.6874	.6265
7 cm	.6154	.6246	.3805	.3750	.6303	.5929	.6321

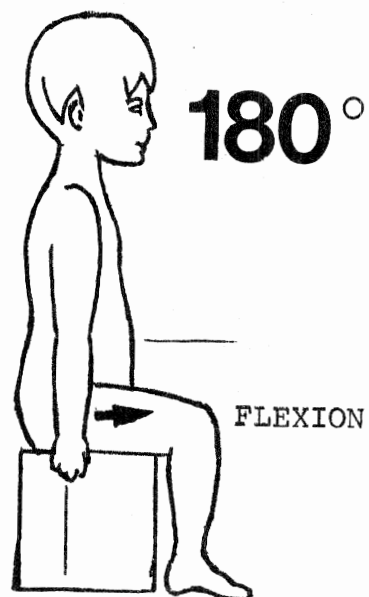
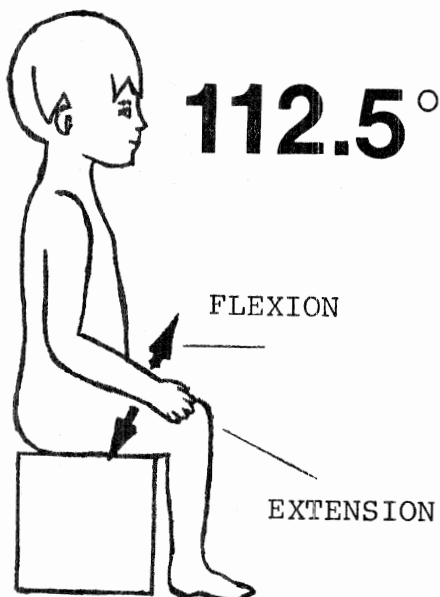
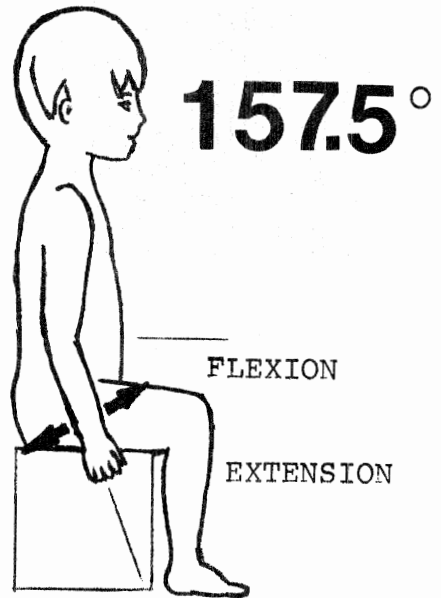
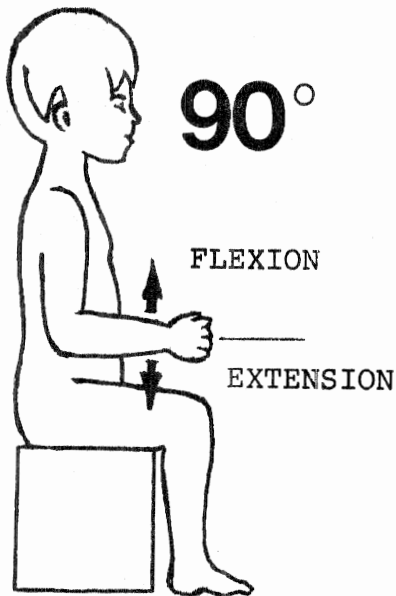
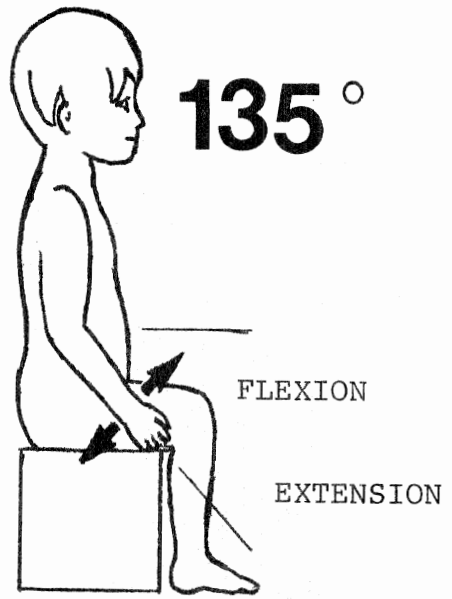
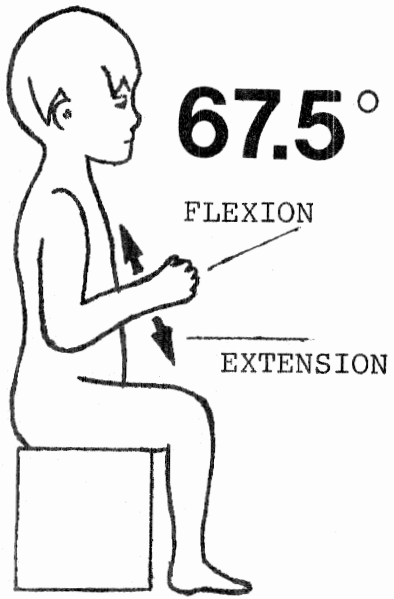
ZERO ORDER CORRELATIONS

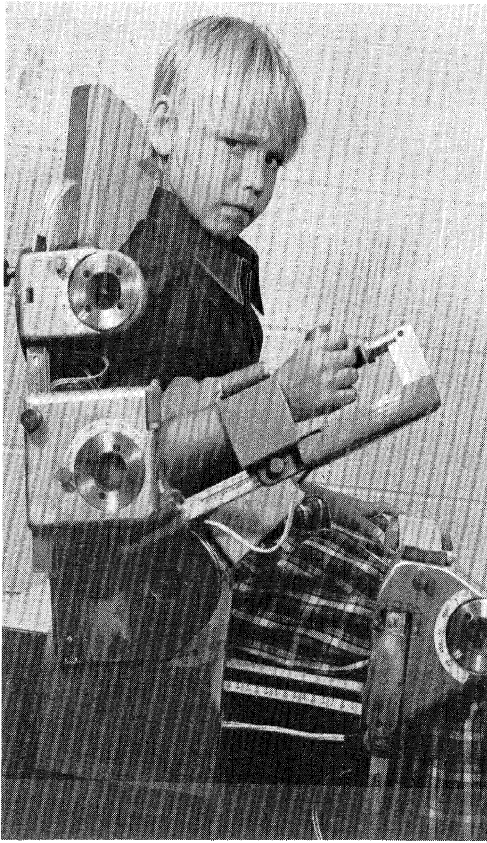
5 Point Pinch

	Height	Weight	Finger Linkage	Cervical Linkage	Hand Length	Hand Breadth	Grip Outside Diameter
2 cm	.8269	.8078	.7451	.6171	.8047	.7670	.8059
3 cm	.8278	.7979	.7502	.6450	.8021	.7765	.7978
4 cm	.8028	.7877	.7319	.6348	.7808	.7661	.7645
5 cm	.7521	.7452	.6917	.6068	.7309	.7297	.7149
6 cm	.7332	.7348	.6483	.5840	.7047	.7321	.6830
7 cm	.6819	.7011	.5970	.5004	.6539	.6954	.6381
8 cm	.4403	.4387	.2787	.3299	.3580	.4029	.3175
9 cm	.0914	.2257	.1605	.0517	.0234	.0285	.1539

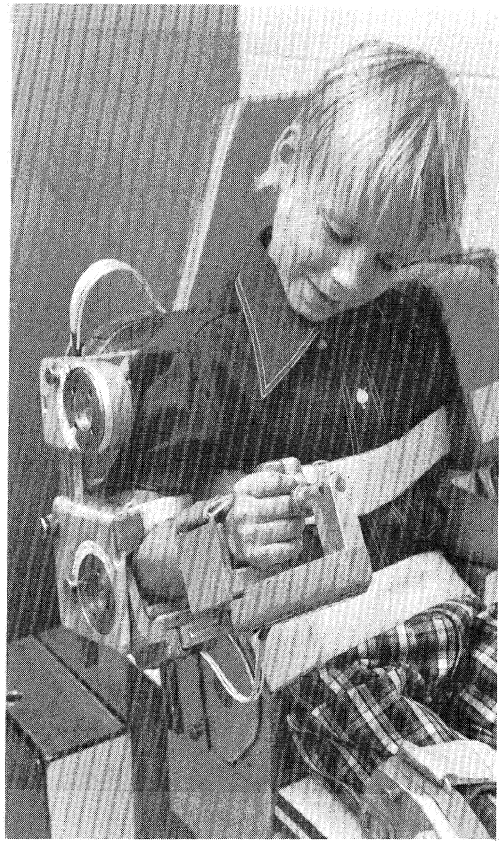


3.4 ELBOW STRENGTH





67.5°



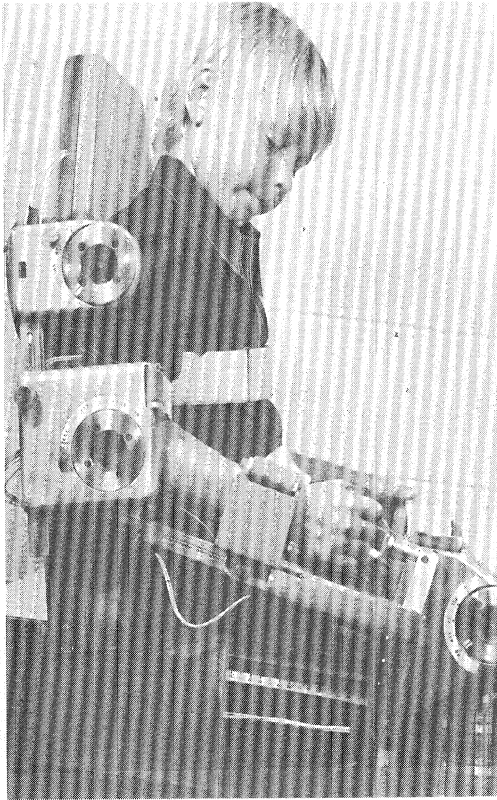
67.5°



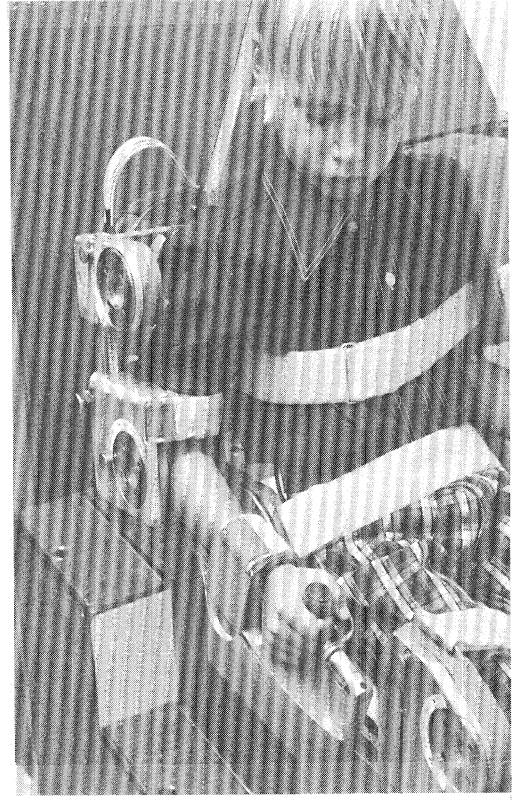
90°



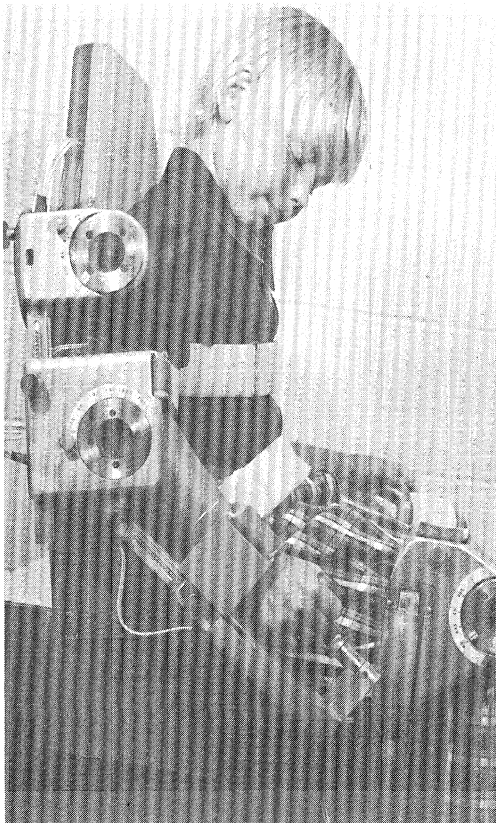
90°



112.5°



112.5°



135°



135°



157.5°



157.5°



180°



180°

### 3.4.1 Index of Elbow Strength Data

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## ELBOW FLEXION

DESCRIPTION OF TEST: The radius and ulna are rotated anteriorly at the elbow joint (humero-ulnar joint center) in the sagittal plane.

TEST POSITION: The shoulder is abducted  $5^{\circ}$ , elbow flexed to the test position, and wrist neutral at  $0^{\circ}$ . The right hand grasps a 2.5 cm diameter handle, the left forearm (distal to the humero-ulnar joint center) is unrestrained.

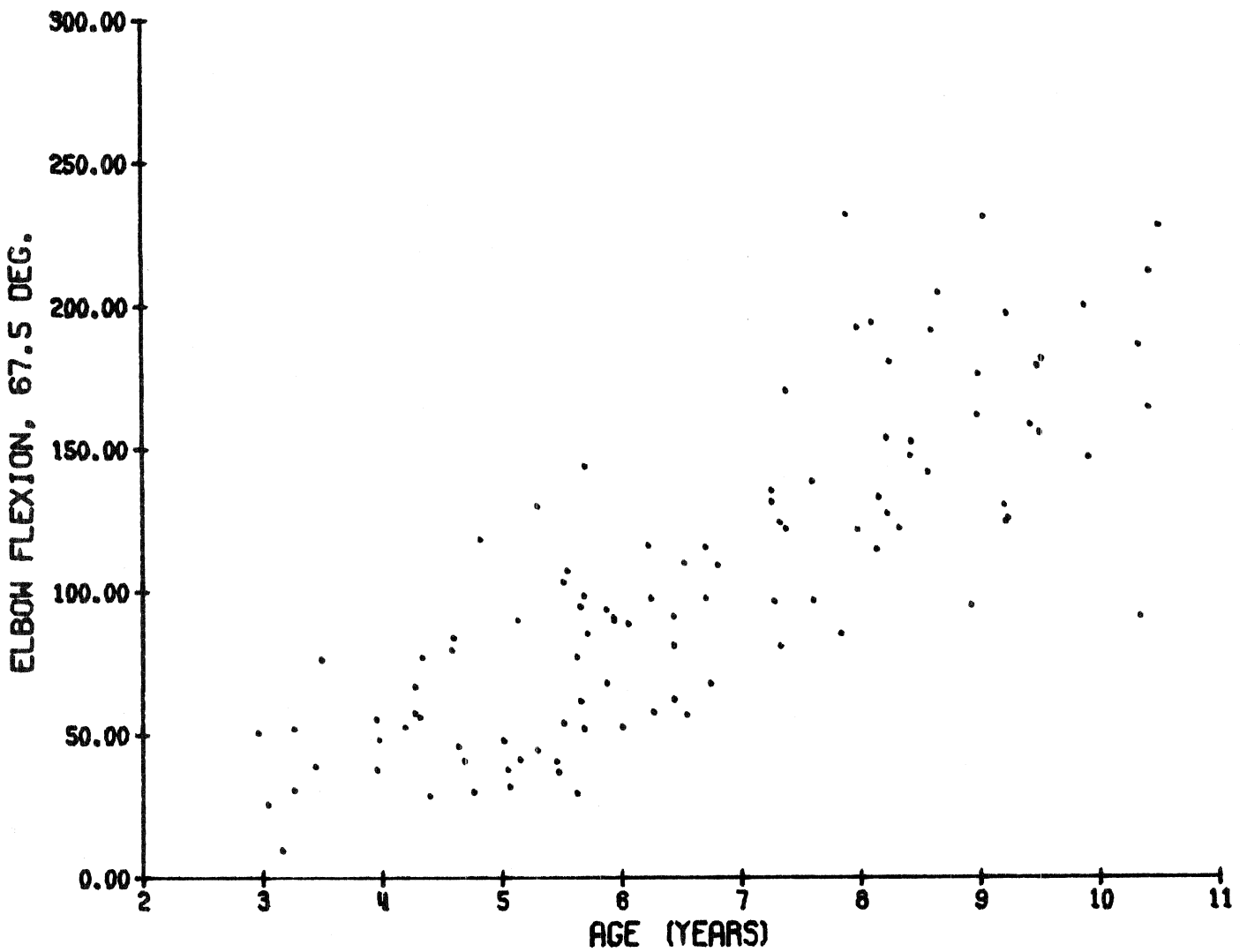
ANTHROPOMETRIC MEASUREMENT: The carpal, radial, humeral, sacral, and thoracolumbar linkages are measured with an anthropometer.

ADJUSTMENT OF EQUIPMENT: The chair back fixture is set to the sacral plus thoracolumbar length, aligning the shoulder joint center with that of the chair. The chair arm fixtures are set to the humeral and radial plus carpal lengths, aligning the elbow joint center and center of grip with those of the chair. Thin rubber pads are placed under the arm as needed to maintain these alignments. The shoulder abduction angle is locked at  $5^{\circ}$  and elbow flexion at test position. The distal edge of the wrist support is adjusted to align with the wrist joint center. The wrist and arm straps are then secured snugly around the arm and the chest strap around the chest and left upper arm. The subject's right hand is placed to grasp the handle on the chair. His left forearm is placed in his lap.

INSTRUCTIONS TO SUBJECT: The child pulls his wrist (and hand) up and his elbow down.

ELBOW FLEXION (67.5 DEG) (Kgf-cm)  
(Males and Females)

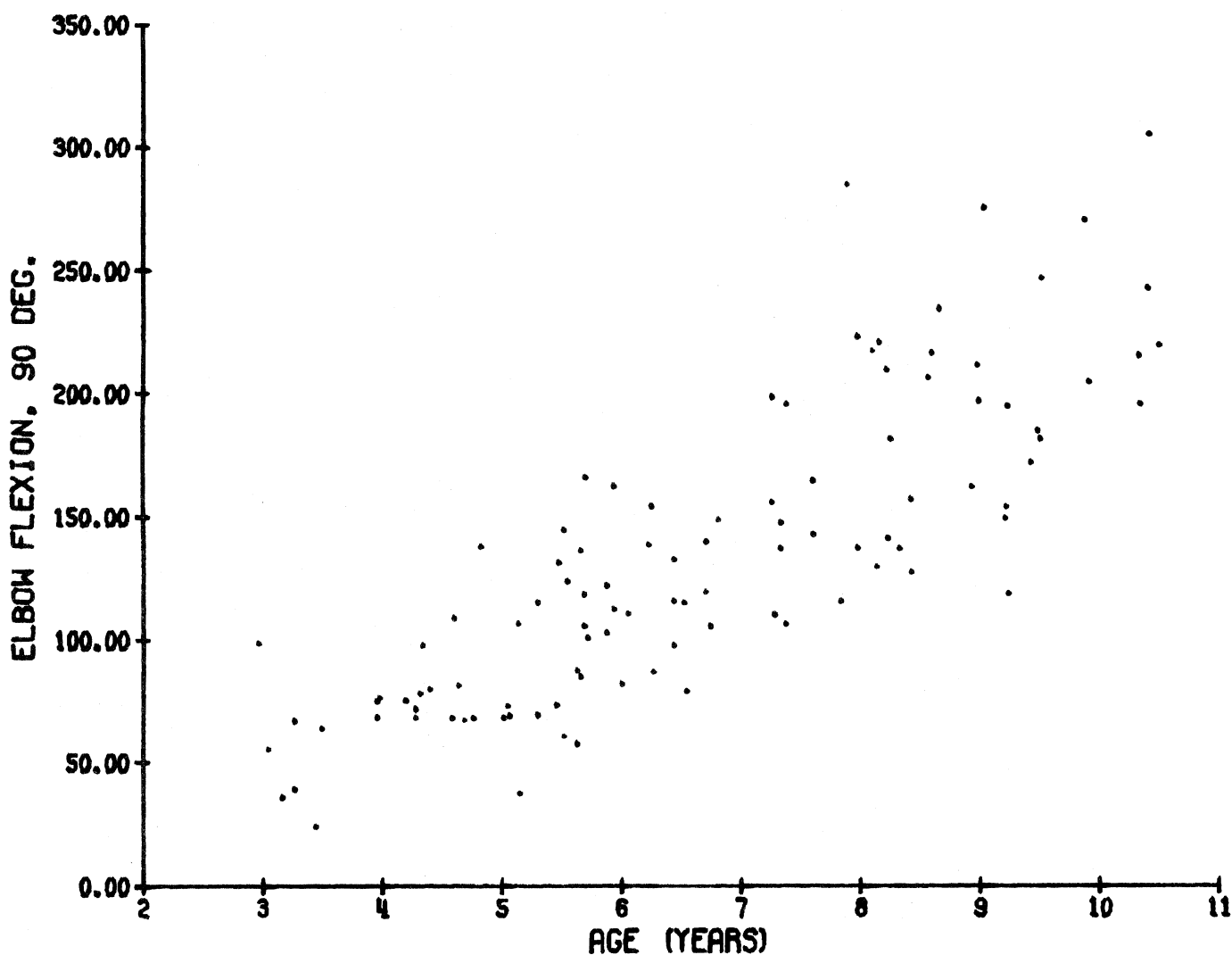
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	40.5	21.6	9.5	10.3	34.8	52.1	76.2
3.5-4.5	9	53.3	14.4	28.5	31.7	54.0	63.5	76.9
4.5-5.5	15	59.8	32.1	29.9	33.0	42.9	88.2	129.6
5.5-6.5	23	82.3	25.2	29.3	53.3	86.8	100.9	143.5
6.5-7.5	13	108.7	30.0	56.8	67.1	109.3	131.2	169.7
7.5-8.5	15	145.5	39.5	84.8	100.8	135.1	188.7	230.9
8.5-9.5	14	161.5	36.9	94.5	123.7	157.5	195.7	229.9
9.5-10.5	8	175.2	42.7	90.4	101.6	180.5	208.3	226.5



ELBOW FLEXION (90 DEG)  
(Males and Females)

(Kgf-cm)

Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	54.6	24.8	23.9	24.5	47.1	66.6	98.3
3.5-4.5	9	76.6	8.9	68.0	68.0	75.1	79.0	97.6
4.5-5.5	15	84.9	28.2	37.3	67.2	71.1	113.5	137.8
5.5-6.5	23	113.1	29.6	57.3	83.2	111.5	141.8	165.9
6.5-7.5	13	135.2	34.9	79.0	103.9	128.1	157.8	198.6
7.5-8.5	15	172.5	48.4	115.3	127.7	149.7	219.8	284.7
8.5-9.5	14	189.8	39.2	118.5	149.6	184.8	215.8	275.1
9.5-10.5	8	237.5	36.7	195.6	197.4	219.7	265.5	305.1

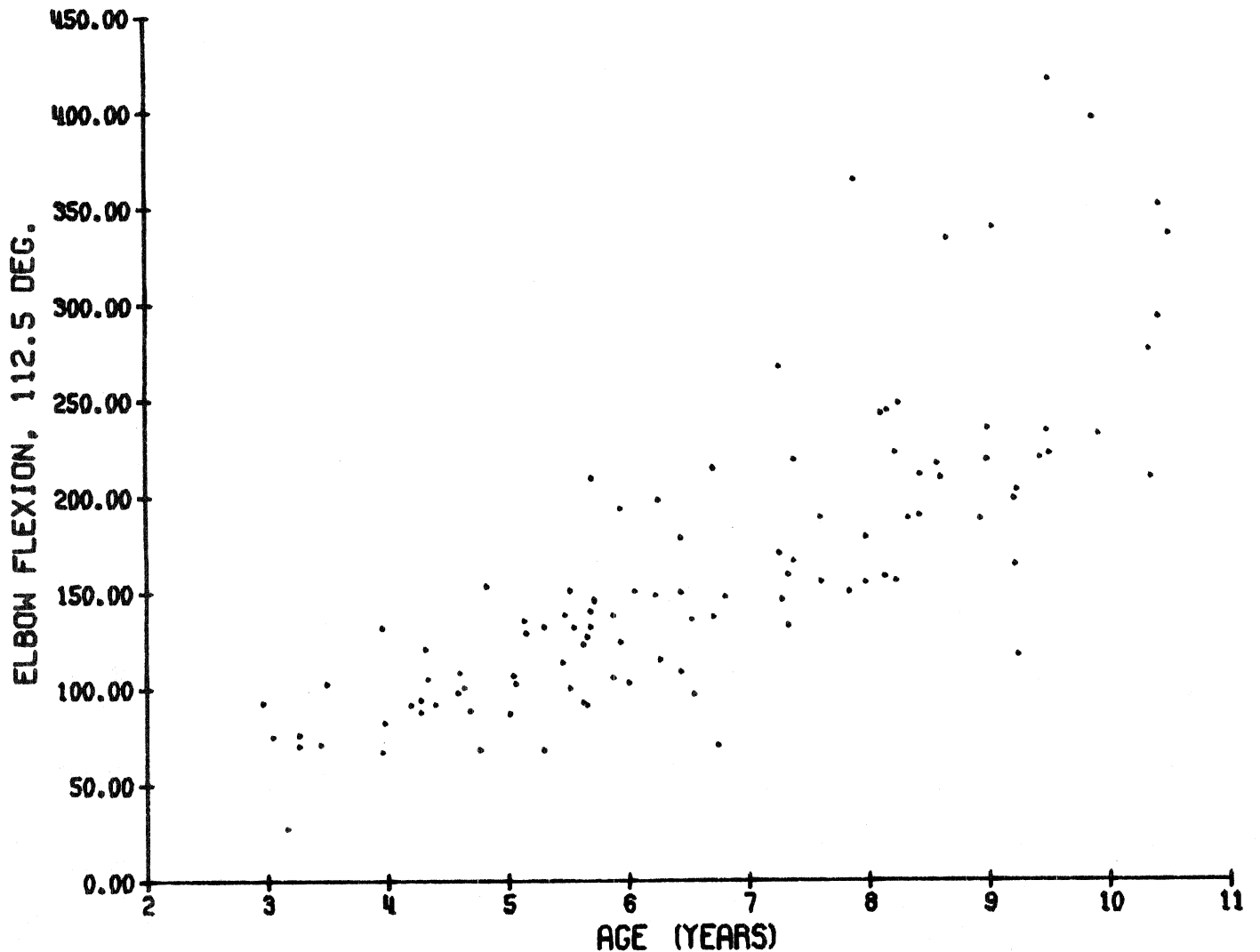




ELBOW FLEXION (112.5 DEG)  
(Males and Females)

(Kgf-cm)

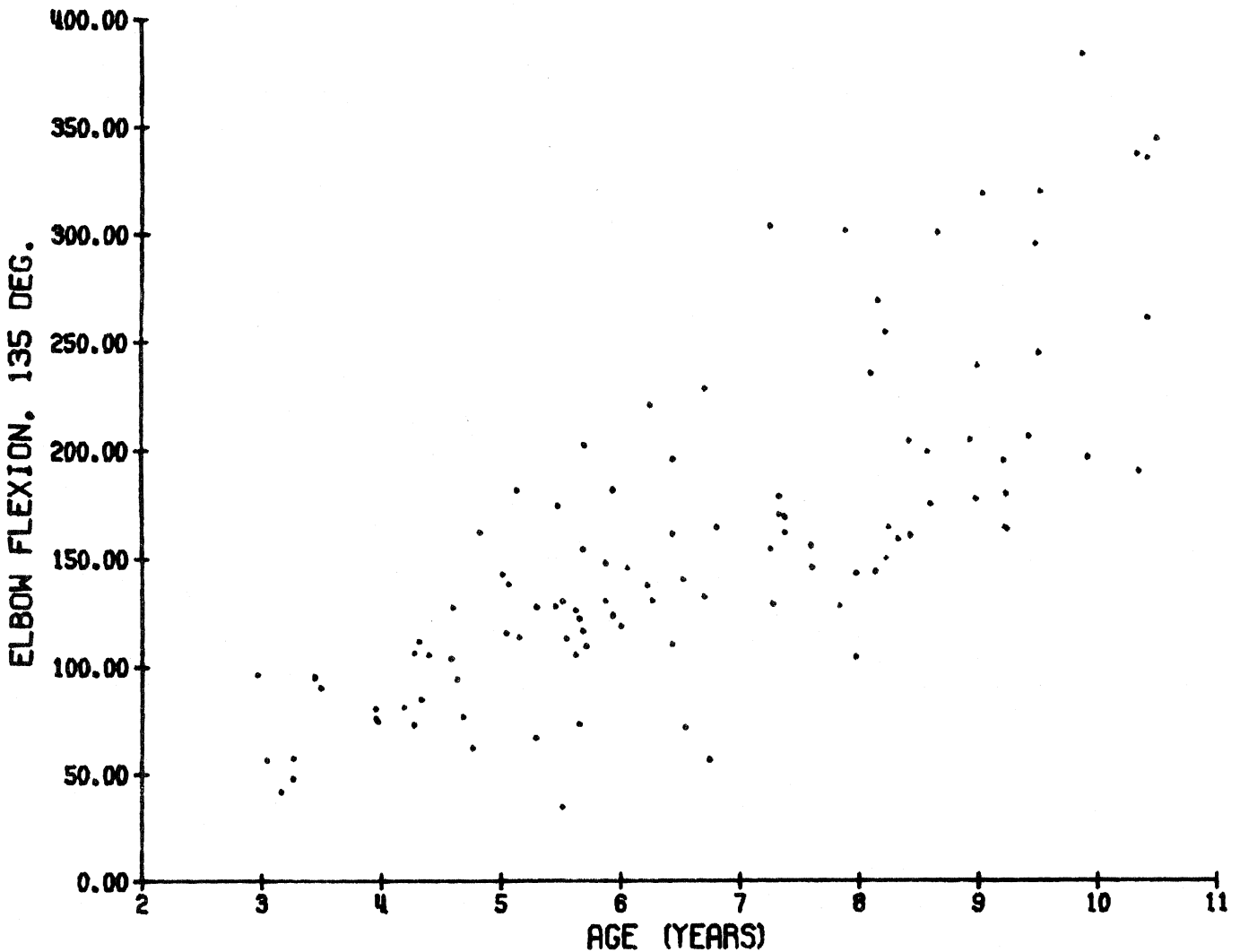
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	73.3	23.6	27.2	29.3	72.7	91.6	102.2
3.5-4.5	9	96.7	19.7	66.8	72.1	91.6	115.0	131.7
4.5-5.5	15	108.3	25.3	67.6	72.5	104.3	134.2	153.0
5.5-6.5	23	137.0	33.0	91.1	101.1	131.8	165.6	209.1
6.5-7.5	13	158.4	51.8	70.0	95.2	146.6	214.6	266.7
7.5-8.5	15	203.1	56.3	149.7	154.6	188.3	243.4	363.2
8.5-9.5	14	220.9	57.5	116.7	166.3	216.5	234.3	338.5
9.5-10.5	8	312.8	74.0	209.3	213.8	291.7	386.0	415.4



ELBOW FLEXION (135 DEG)  
(Males and Females)

(Kgf-cm)

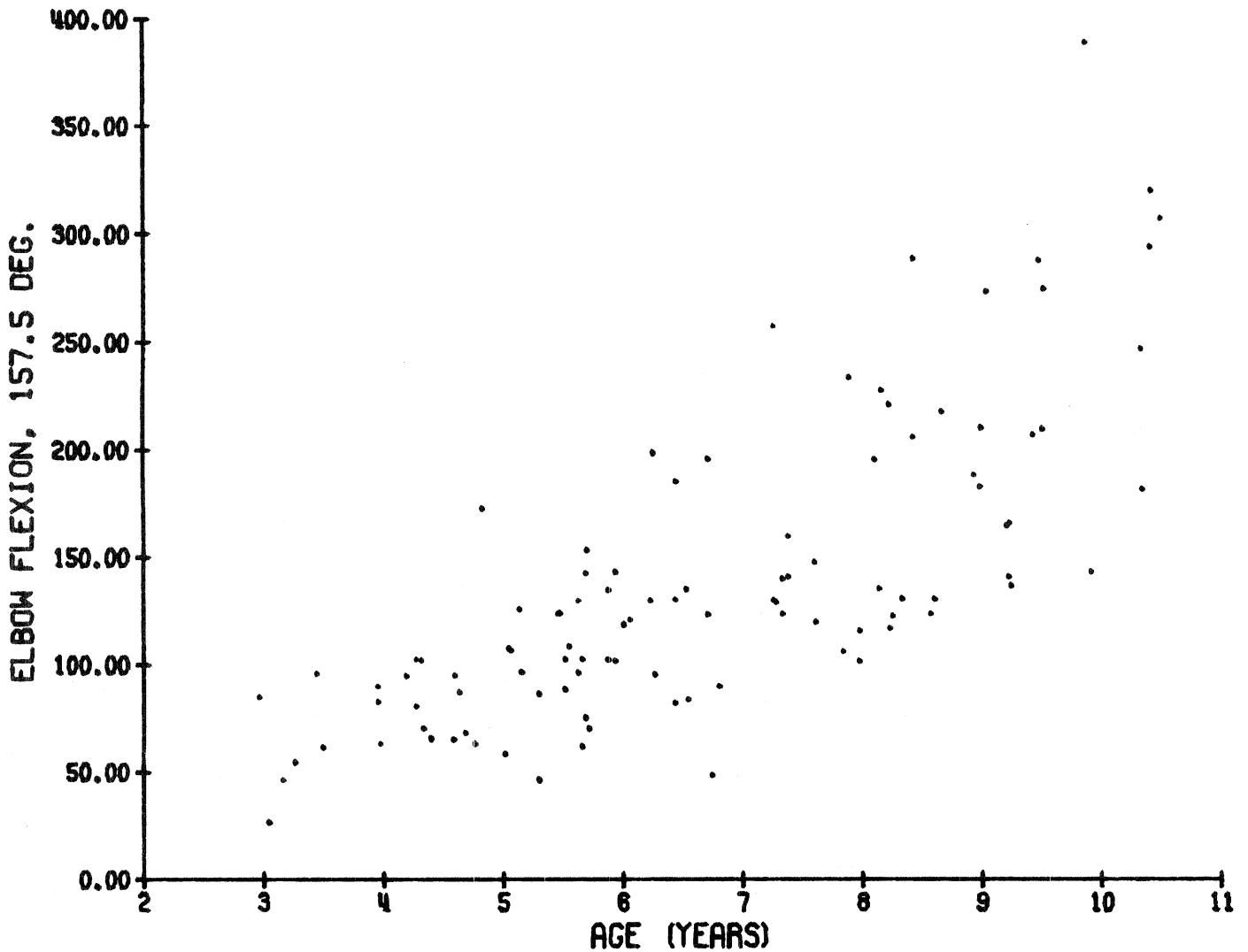
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	69.1	23.6	41.7	42.0	56.7	94.7	96.1
3.5-4.5	9	87.9	15.3	72.6	73.2	80.8	105.9	111.4
4.5-5.5	15	120.8	36.4	62.1	69.0	121.3	156.9	181.1
5.5-6.5	23	134.3	40.8	34.7	107.0	128.0	172.3	220.6
6.5-7.5	13	158.3	62.3	56.4	70.6	157.9	180.9	303.4
7.5-8.5	15	181.1	57.7	104.2	131.5	157.1	249.6	301.3
8.5-9.5	14	218.6	52.7	163.2	164.9	199.1	290.1	318.4
9.5-10.5	8	295.7	71.7	190.0	191.3	319.2	342.4	383.5



ELBOW FLEXION (157.5 DEG)  
(Males and Females)

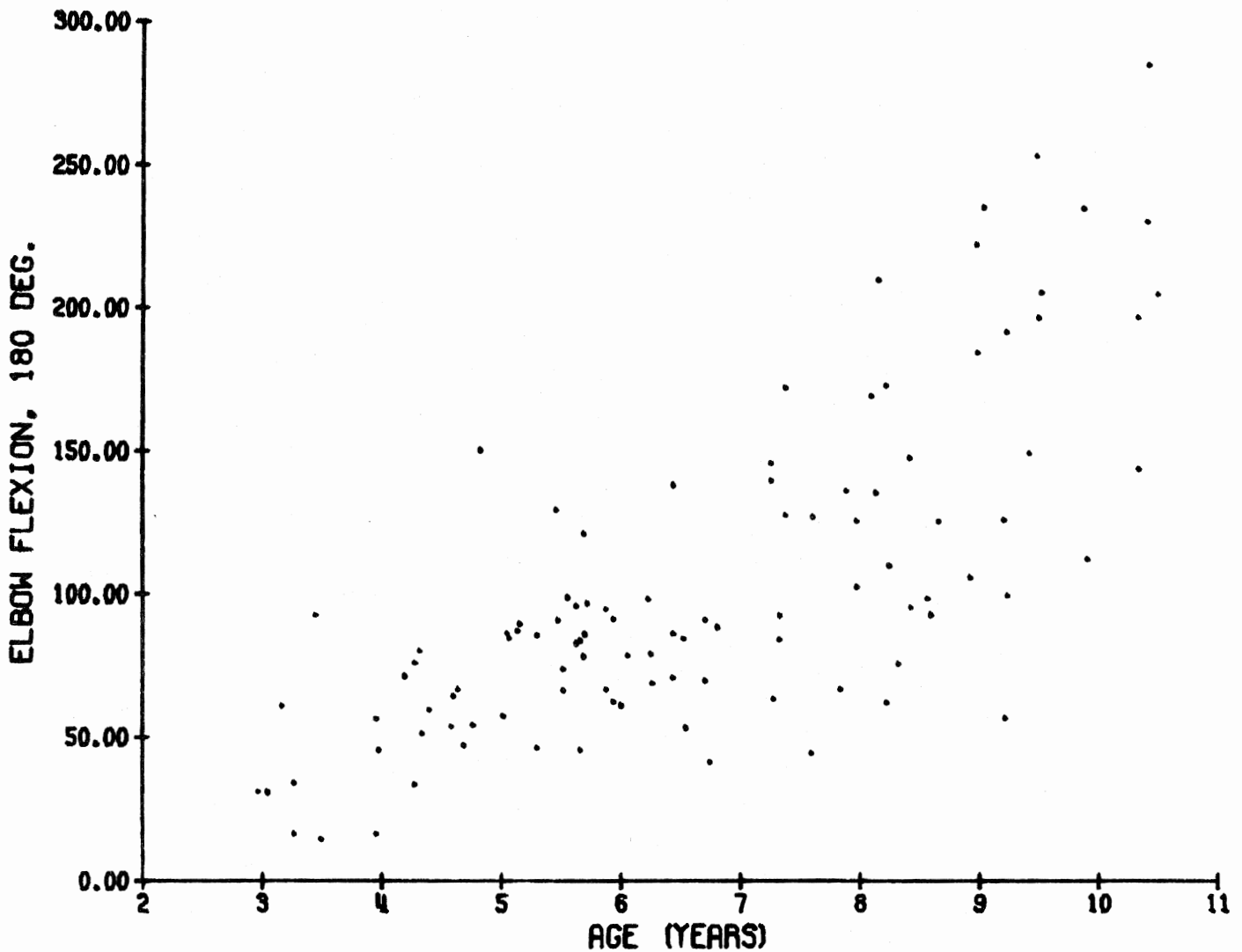
(Kgf-cm)

Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	6	61.4	25.4	26.3	**	54.5	**	95.7
3.5-4.5	9	83.3	15.0	62.8	63.8	81.3	99.3	102.3
4.5-5.5	15	94.9	33.1	46.2	59.4	90.9	123.7	172.0
5.5-6.5	23	116.0	34.0	61.7	78.1	105.3	142.6	198.0
6.5-7.5	13	134.8	51.3	48.4	81.8	129.1	161.0	256.6
7.5-8.5	15	164.1	58.4	101.3	108.3	132.5	225.3	287.9
8.5-9.5	14	187.9	50.1	123.2	130.7	182.1	216.3	286.9
9.5-10.5	8	268.6	78.0	143.0	150.6	273.7	316.2	387.4



ELBOW FLEXION (180 DEG)  
(Males and Females) (Kgf-cm)

Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	40.0	27.7	14.5	14.6	30.8	59.6	92.6
3.5-4.5	9	54.6	20.7	16.6	22.5	53.9	74.6	80.5
4.5-5.5	15	79.8	29.6	46.3	49.0	75.9	90.8	150.5
5.5-6.5	23	84.0	20.1	45.7	64.4	81.3	98.0	138.5
6.5-7.5	13	96.9	38.9	41.5	53.0	86.9	140.5	172.6
7.5-8.5	15	119.3	45.9	44.8	63.8	118.4	164.5	210.6
8.5-9.5	14	153.5	61.1	57.2	94.0	126.8	220.6	254.2
9.5-10.5	8	202.7	53.8	113.2	119.5	206.0	235.1	286.1



## ELBOW EXTENSION

DESCRIPTION OF TEST: The radius and ulna are rotated posteriorly at the elbow joint (humero-ulnar joint center) in the sagittal plane.

TEST POSITION: The shoulder is abducted 5°, elbow flexed to test position, and wrist neutral at 0°. The right hand grasps a 2.5 cm diameter handle, the left forearm (distal to the humero-ulnar joint center) is unrestrained.

ANTHROPOMETRIC MEASUREMENT: The carpal, radial, humeral, sacral, and thoracolumbar linkages are measured with an anthropometer.

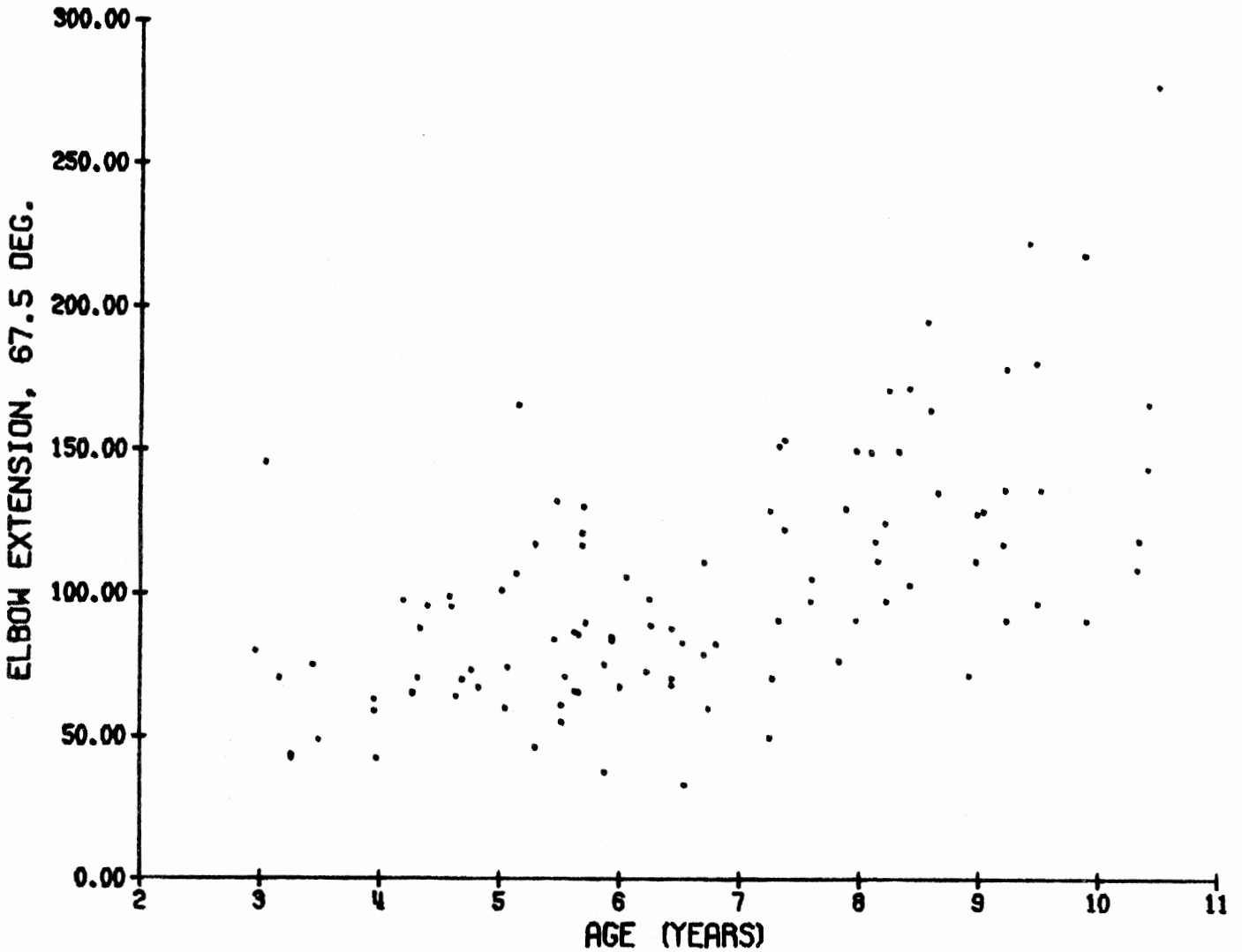
ADJUSTMENT OF EQUIPMENT: The chair back fixture is set to the sacral plus thoracolumbar length, aligning the shoulder joint to the humeral and radial plus carpal lengths, aligning the elbow joint center and center of grip with those of the chair. Thin rubber pads are placed under the arm as needed to maintain these alignments. The shoulder abduction angle is locked at 5° and elbow flexion at the test position. The distal edge of the wrist support is adjusted to align with the wrist joint center. The wrist and arm straps are then secured snugly around the arm and the chest strap around the chest and left upper arm. The subject's right hand is placed to grasp the handle on the chair. His left forearm is placed in his lap.

INSTRUCTIONS TO SUBJECT: The child pushes his wrist (and hand) down and his elbow up.

ELBOW EXTENSION (67.5 DEG)  
(Males and Females)

(Kgf-cm)

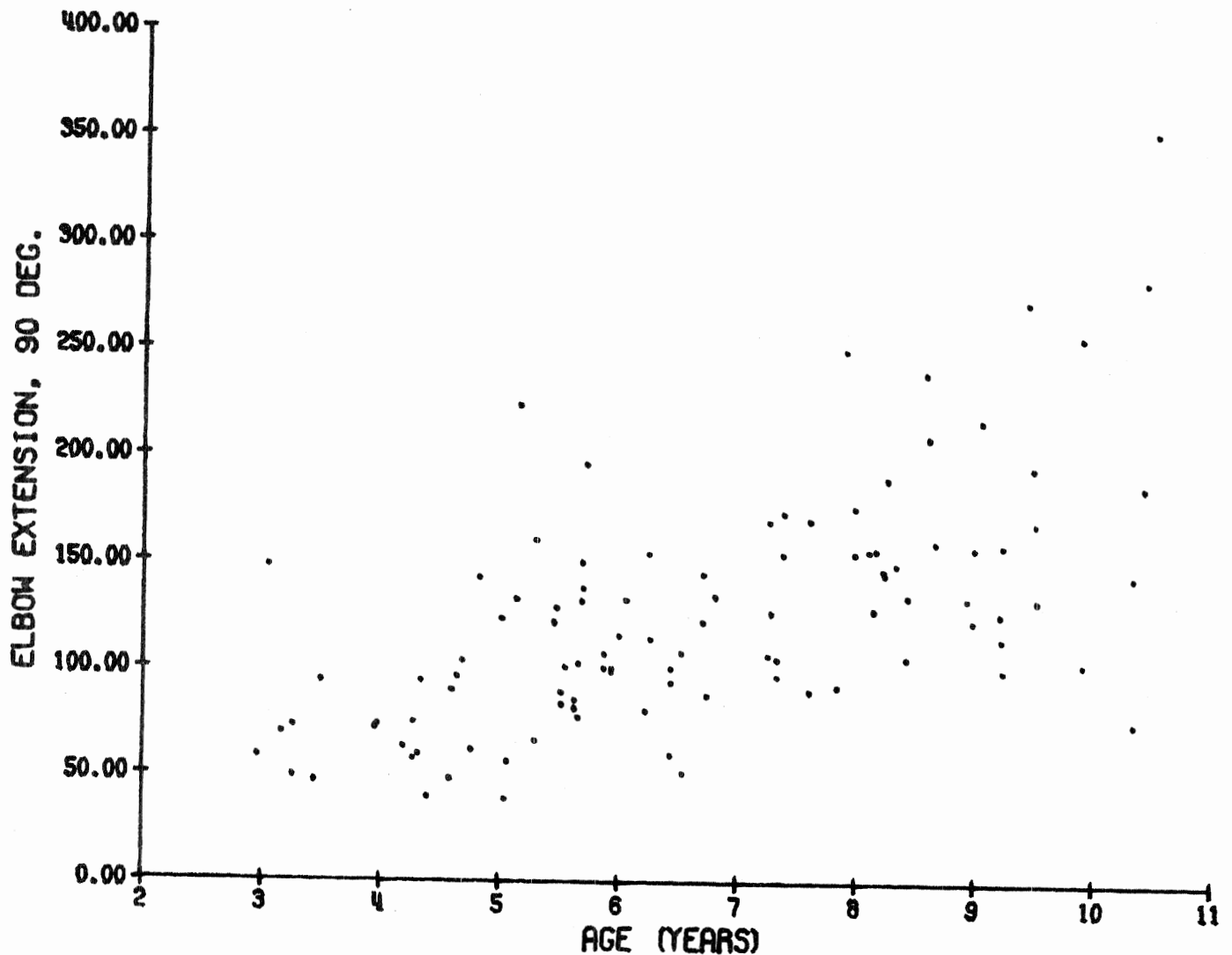
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	72.3	35.8	42.7	42.8	59.7	79.7	145.6
3.5-4.5	9	72.0	18.3	42.6	48.4	65.4	93.1	97.8
4.5-5.5	15	90.7	31.3	46.5	61.3	79.3	114.9	165.9
5.5-6.5	23	82.4	21.9	37.8	63.3	79.7	102.7	130.5
6.5-7.5	13	93.9	37.8	33.3	49.3	82.9	130.6	154.0
7.5-8.5	15	123.7	29.6	76.9	93.0	115.6	150.3	172.4
8.5-9.5	14	140.5	43.1	72.1	92.2	129.6	181.2	223.2
9.5-10.5	8	158.3	62.3	91.4	95.0	137.0	208.6	278.3



ELBOW EXTENSION (90 DEG)  
(Males and Females)

(Kgf-cm)

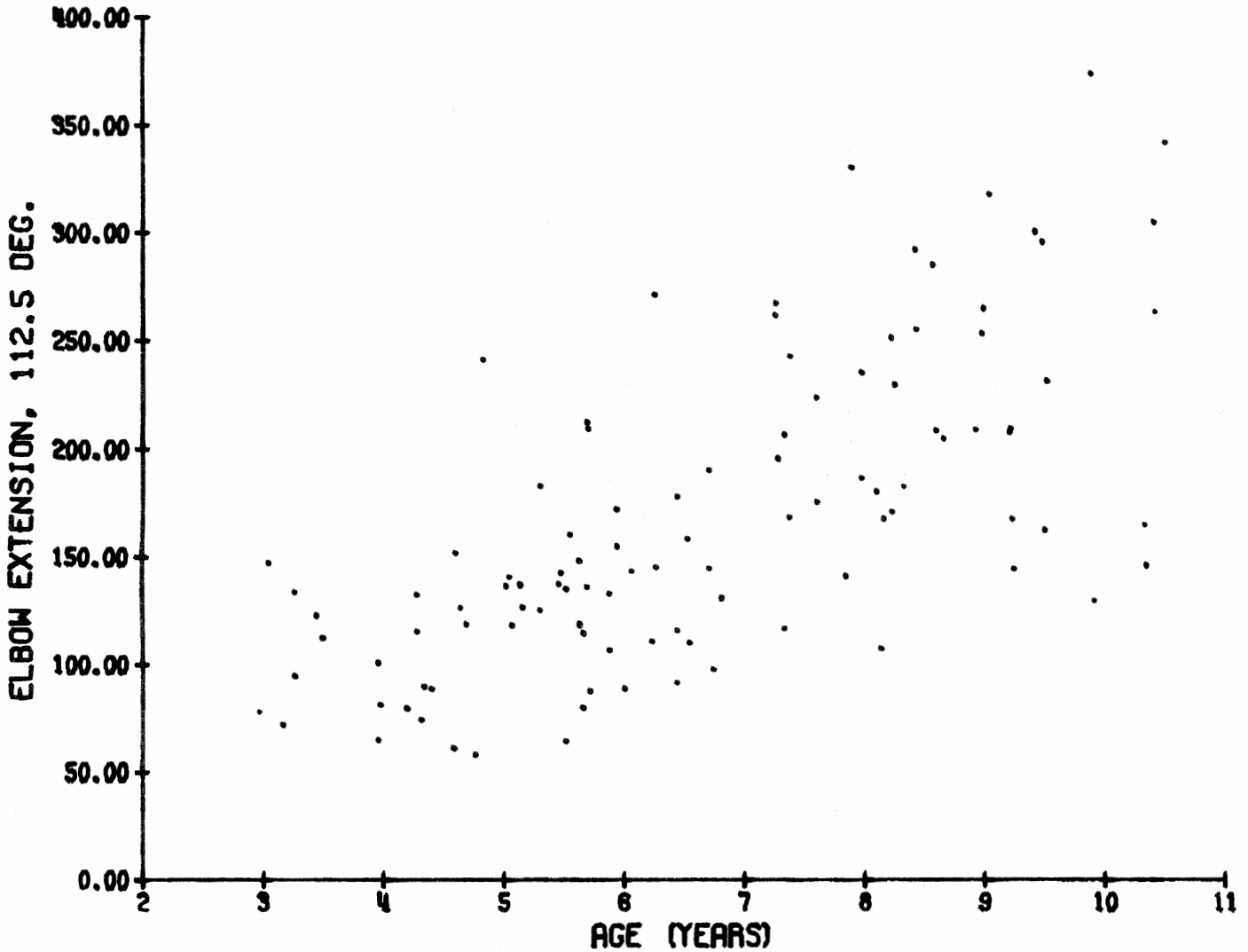
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	77.0	35.1	47.1	47.2	64.0	93.2	147.7
3.5-4.5	9	67.3	15.0	39.4	45.7	67.6	74.2	94.2
4.5-5.5	15	106.0	49.3	38.5	50.1	100.0	139.9	223.0
5.5-6.5	23	108.2	30.5	59.6	80.5	100.4	135.1	195.6
6.5-7.5	13	121.2	34.2	51.3	85.6	114.9	154.4	172.3
7.5-8.5	15	149.2	39.8	89.9	95.3	147.6	174.1	248.9
8.5-9.5	14	169.1	50.6	99.5	115.1	158.1	215.3	271.9
9.5-10.5	8	191.1	96.4	75.2	80.8	143.7	276.6	351.5



ELBOW EXTENSION (112.5 DEG)  
(Males and Females)

(Kgf-cm)

Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	108.4	28.3	71.7	72.0	103.3	133.1	146.8
3.5-4.5	9	91.7	21.2	64.7	68.0	84.7	110.2	132.3
4.5-5.5	15	133.6	43.2	57.7	75.3	131.4	149.4	241.2
5.5-6.5	23	138.1	48.3	64.2	88.1	134.0	175.4	271.5
6.5-7.5	13	176.3	57.2	97.6	109.5	163.5	244.0	267.6
7.5-8.5	15	208.8	58.7	107.5	147.7	184.6	254.7	330.6
8.5-9.5	14	231.1	55.6	144.6	163.2	209.2	295.3	318.2
9.5-10.5	8	245.1	92.6	130.0	133.2	231.8	335.4	374.7

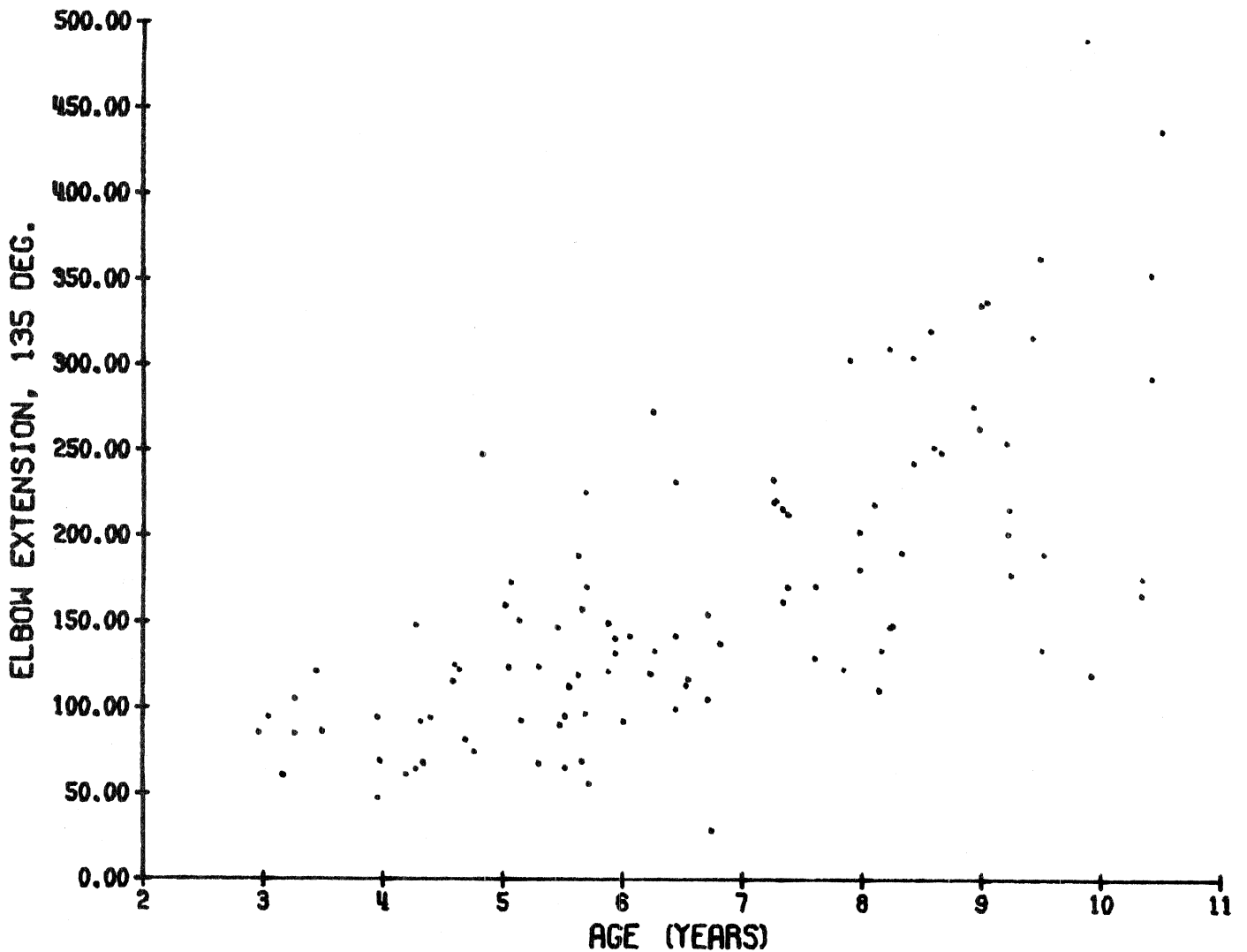




ELBOW EXTENSION (135 DEG)  
(Males and Females)

(Kgf-cm)

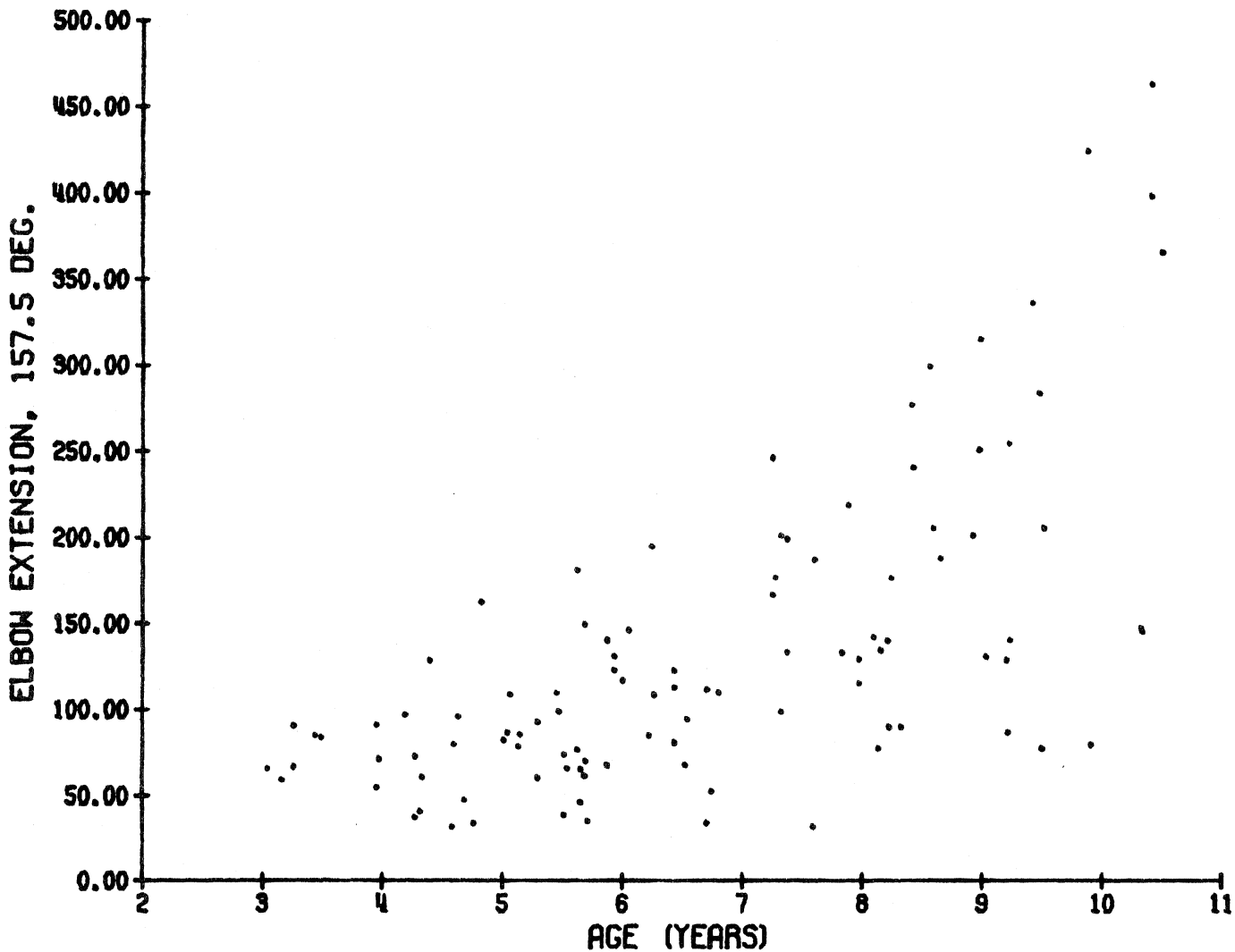
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	7	90.7	18.9	60.2	61.4	85.5	104.1	120.7
3.5-4.5	9	81.8	29.7	47.3	52.1	68.1	94.1	147.8
4.5-5.5	15	125.9	46.1	67.2	75.7	122.6	157.0	247.1
5.5-6.5	23	135.7	54.0	55.7	78.8	126.2	179.8	272.1
6.5-7.5	13	160.3	60.0	28.8	100.8	157.9	219.1	232.5
7.5-8.5	15	193.7	68.2	110.2	123.8	175.2	287.1	309.0
8.5-9.5	14	263.2	66.1	133.8	179.7	253.7	332.5	361.7
9.5-10.5	8	276.9	136.9	118.8	128.1	188.9	418.6	488.1

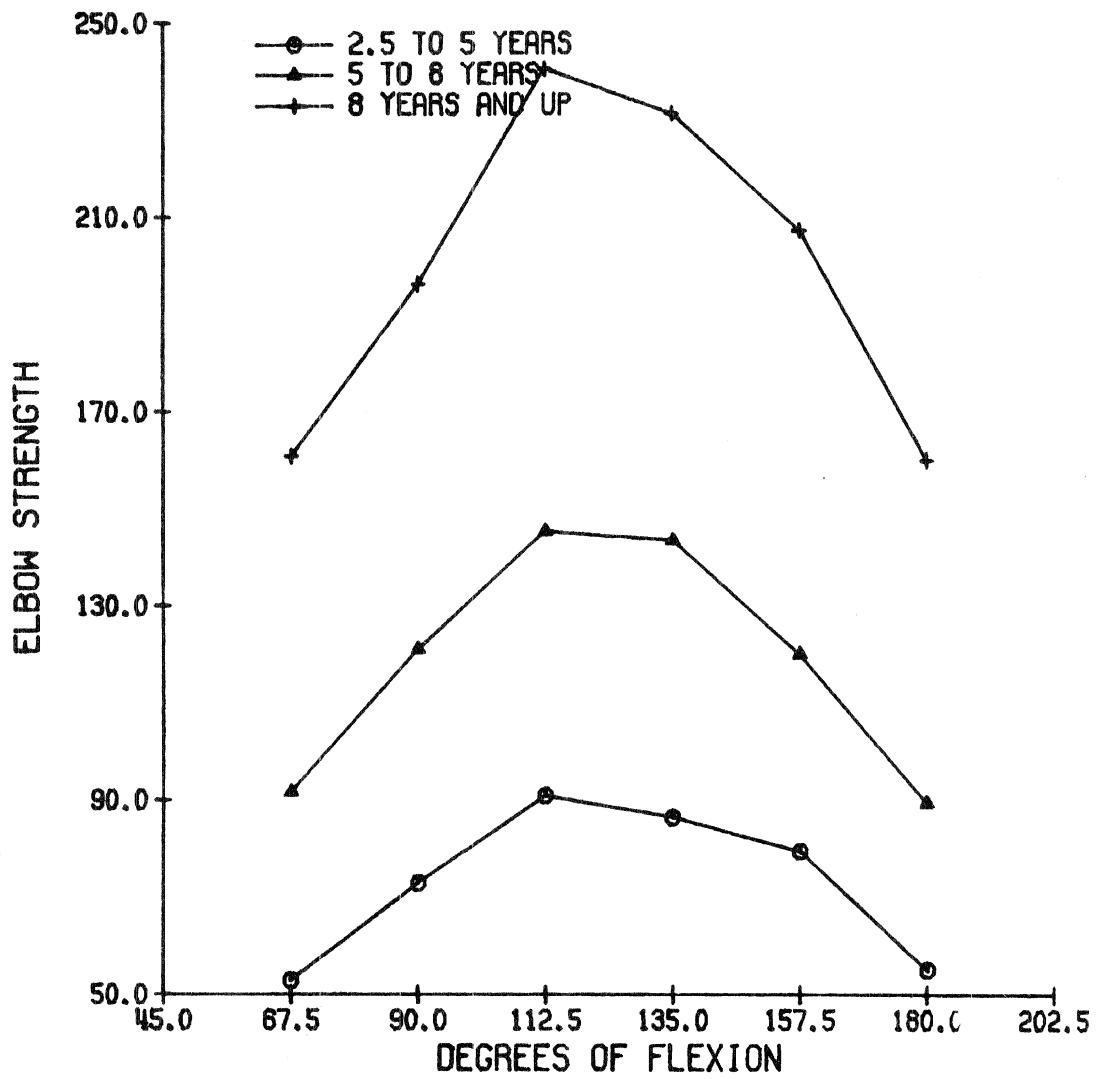


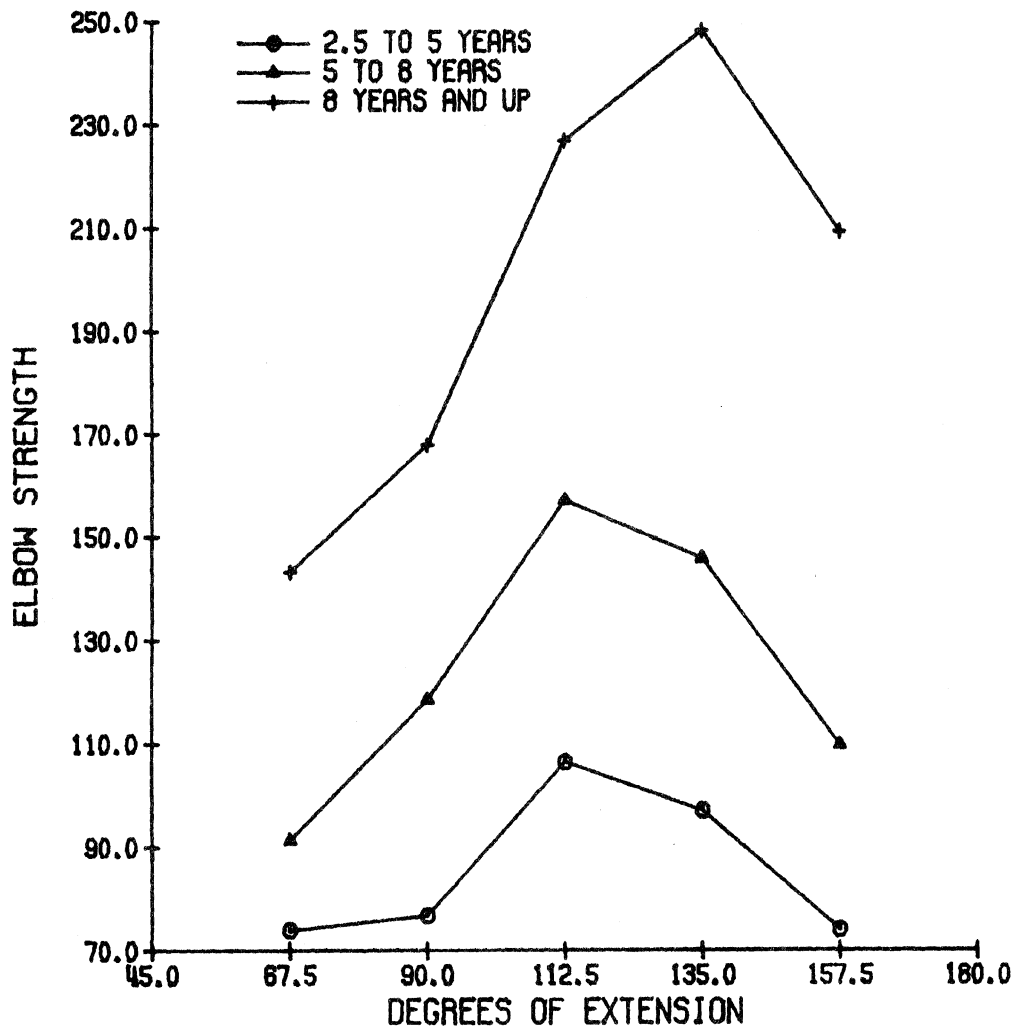
ELBOW EXTENSION (157.5 DEG)  
(Males and Females)

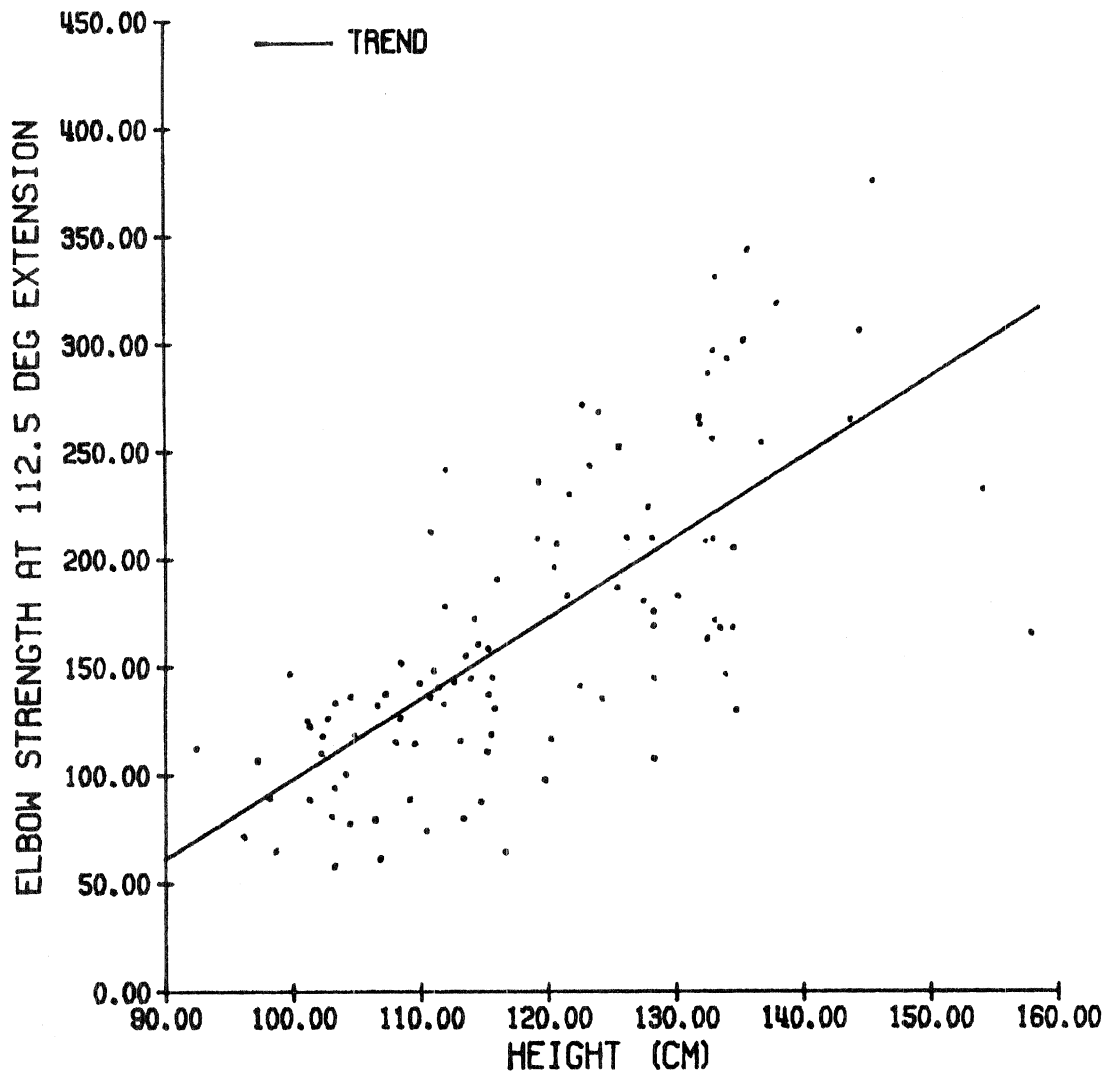
(Kgf-cm)

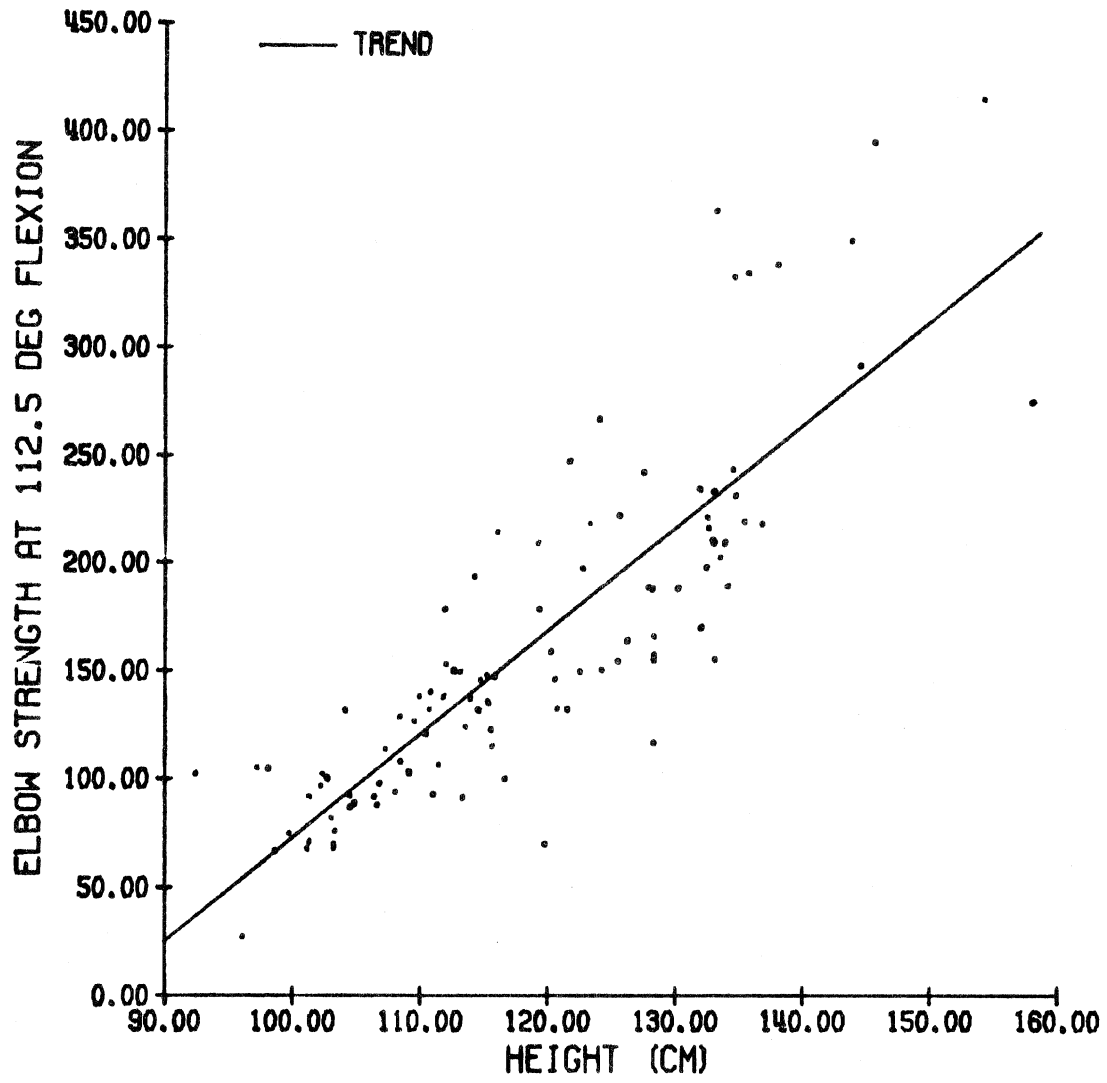
Age (yrs)	N	Mean	s.d.	Min	15th	50th	85th	Max
2.5-3.5	6	75.0	13.0	58.8	**	66.4	**	90.5
3.5-4.5	9	72.5	29.1	37.1	38.4	65.8	94.7	128.5
4.5-5.5	15	83.5	32.8	31.7	37.3	83.6	106.0	162.5
5.5-6.5	23	99.5	44.0	35.0	53.0	82.8	143.2	194.6
6.5-7.5	13	130.0	63.9	34.1	51.5	110.5	199.2	246.0
7.5-8.5	15	145.4	65.3	32.0	80.4	133.5	210.7	277.0
8.5-9.5	14	206.8	85.5	77.2	90.7	201.1	297.7	335.9
9.5-10.5	8	278.5	149.8	79.5	92.7	205.4	418.8	462.9

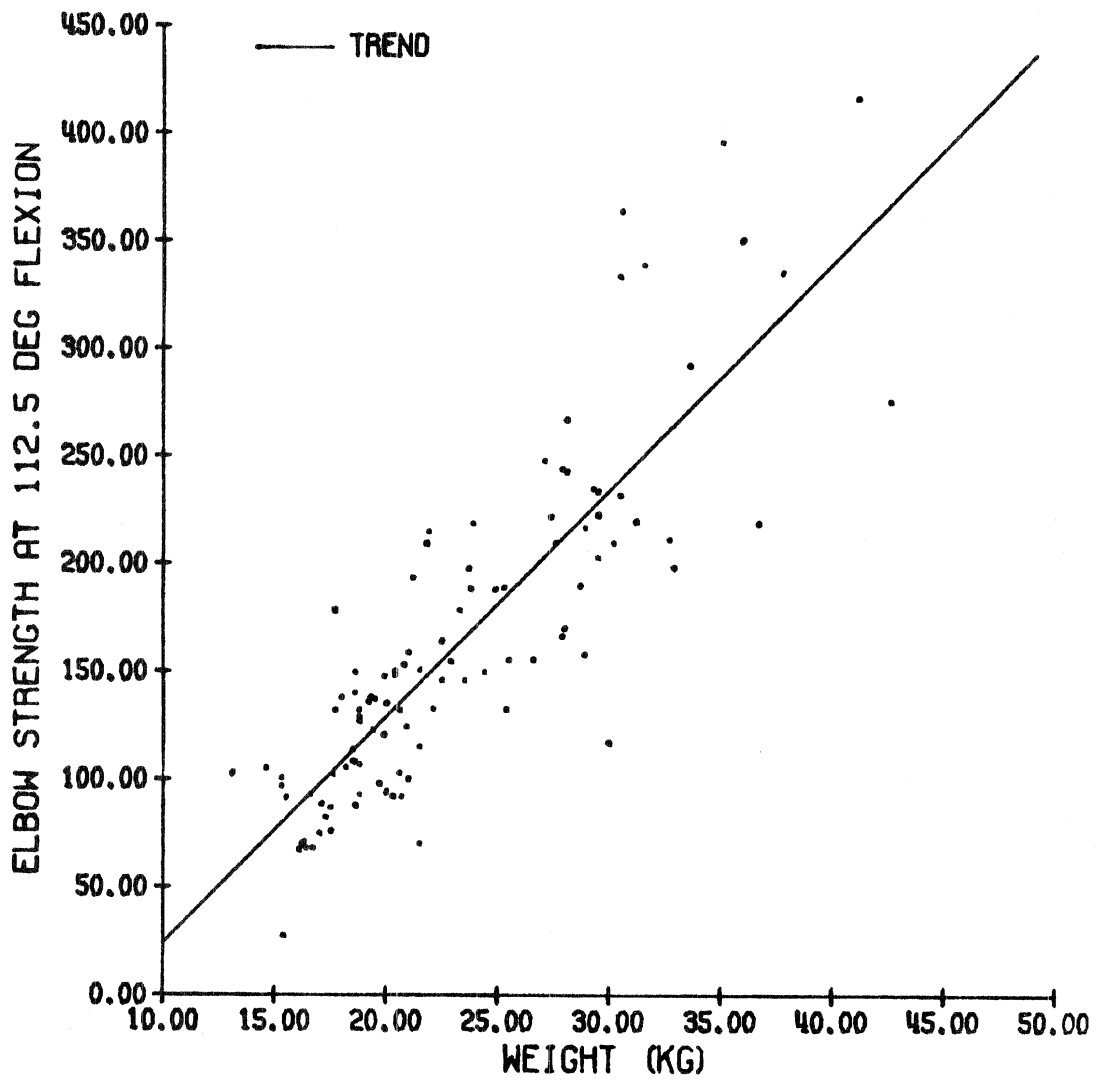


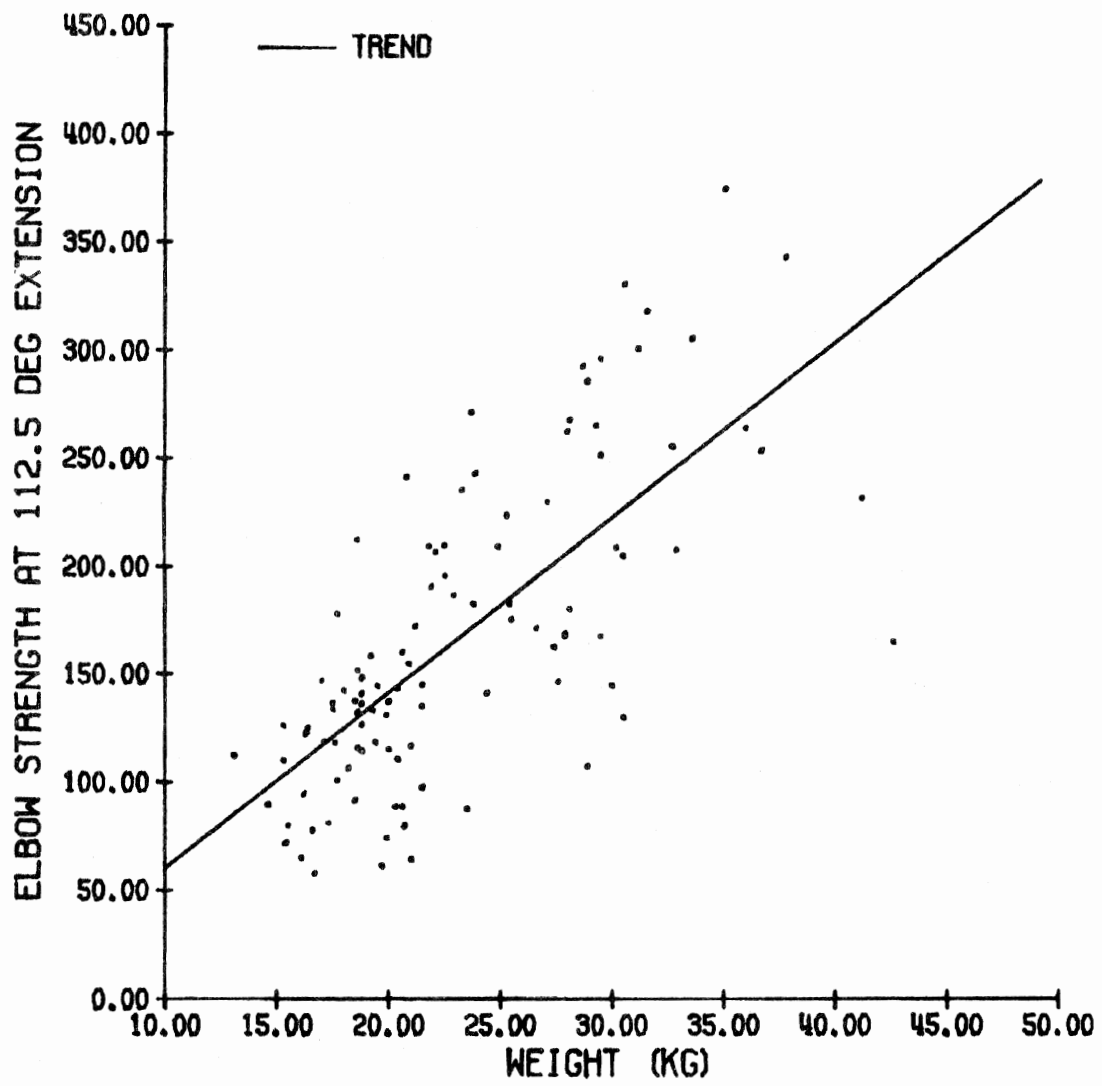




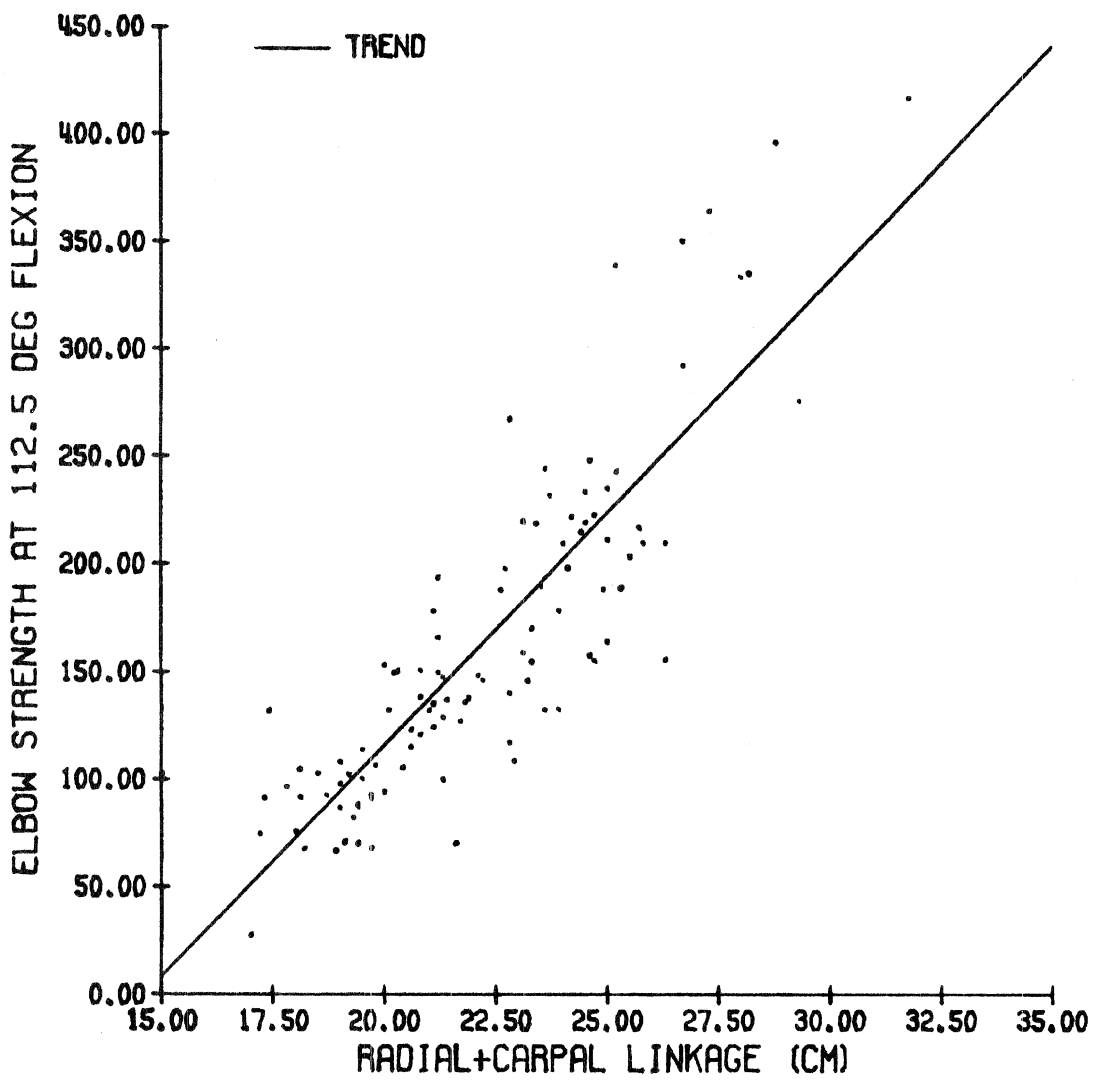


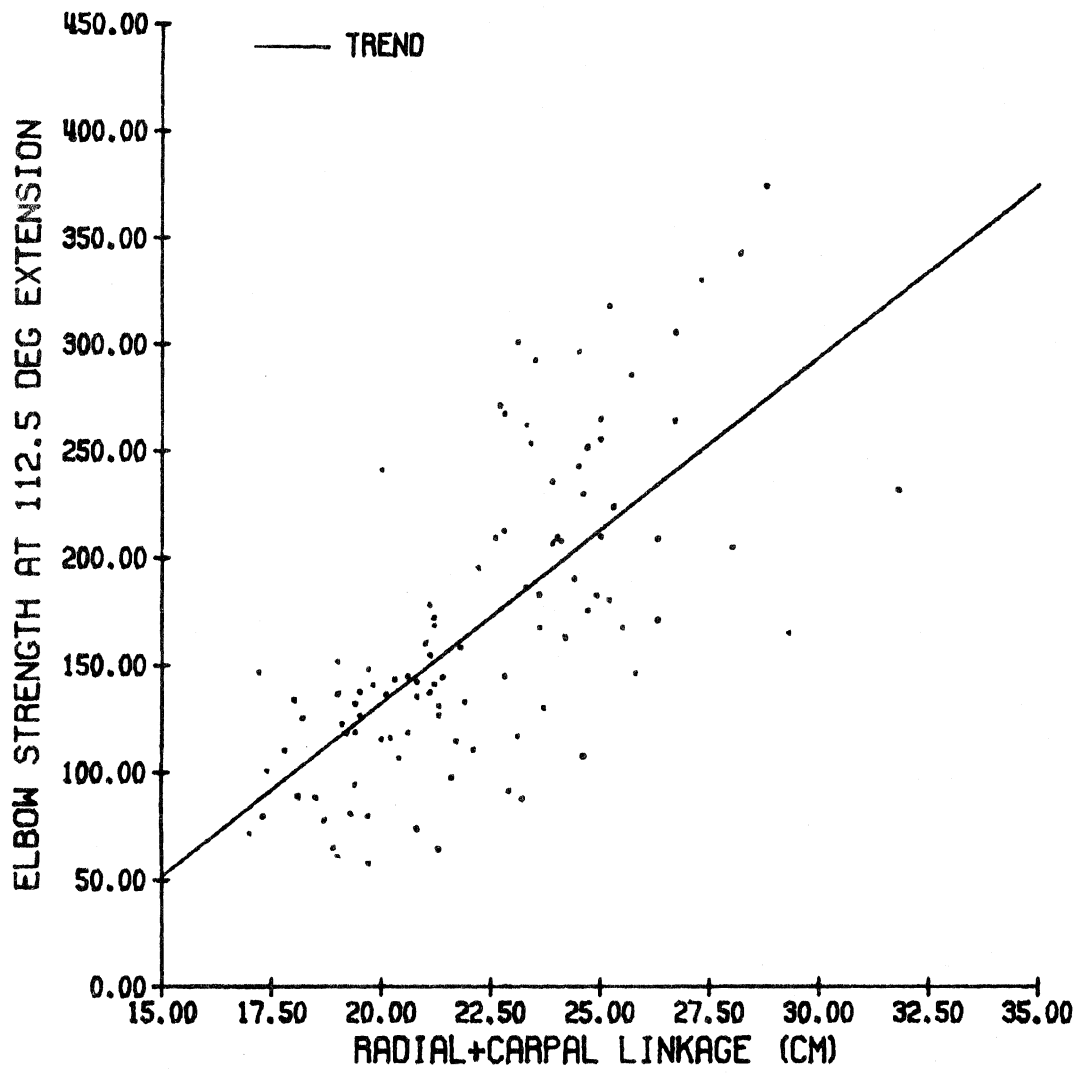












Elbow Strength Statistics  
(2.5 - 3.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	7	72.3	35.8	42.7	42.8	59.7	79.7	145.6
Elbow Extension, 90 deg	7	77.0	35.1	47.1	47.2	64.0	93.2	147.7
Elbow Extension, 112.5 deg	7	108.4	28.3	71.7	72.0	103.3	133.1	146.8
Elbow Extension, 135 deg	7	90.7	18.9	60.2	61.4	85.5	104.1	120.7
Elbow Extension, 157.5 deg	6	75.0	13.0	58.8	**	66.4	**	90.5
Elbow Flexion, 67.5 deg	7	40.5	21.6	9.5	10.3	34.8	52.1	76.2
Elbow Flexion, 90 deg	7	54.6	24.8	23.9	24.5	47.1	66.6	98.3
Elbow Flexion, 112.5 deg	7	73.3	23.6	27.2	29.3	72.7	91.6	102.2
Elbow Flexion, 135 deg	7	69.1	23.6	41.7	42.0	56.7	94.7	96.1
Elbow Flexion, 157.5 deg	6	61.4	25.4	26.3	**	54.5	**	95.7
Elbow Flexion, 180 deg	7	40.0	27.7	14.5	14.6	30.8	59.6	92.6

Elbow Strength Statistics  
(3.5 - 4.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	9	72.0	18.3	42.6	48.4	65.4	93.1	97.8
Elbow Extension, 90 deg	9	67.3	15.0	39.4	45.7	67.6	74.2	94.2
Elbow Extension, 112.5 deg	9	91.7	21.2	64.7	68.0	84.7	110.2	132.3
Elbow Extension, 135 deg	9	81.8	29.7	47.3	52.1	68.1	94.1	147.8
Elbow Extension, 157.5 deg	9	72.5	29.1	37.1	38.4	65.8	94.7	128.5
Elbow Flexion, 67.5 deg	9	53.3	14.4	28.5	31.7	54.0	63.5	76.9
Elbow Flexion, 90 deg	9	76.6	8.9	68.0	68.0	75.1	79.0	97.6
Elbow Flexion, 112.5 deg	9	96.7	19.7	66.8	72.1	91.6	115.0	131.7
Elbow Flexion, 135 deg	9	87.9	15.3	72.6	73.2	80.8	105.9	111.4
Elbow Flexion, 157.5 deg	9	83.3	15.0	62.8	63.8	81.3	99.3	102.3
Elbow Flexion, 180 deg	9	54.6	20.7	16.6	22.5	53.9	74.6	80.5

Elbow Strength Statistics  
(4.5 - 5.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	15	90.7	31.3	46.5	61.3	79.3	114.9	165.9
Elbow Extension, 90 deg	15	106.0	49.3	38.5	50.1	100.0	139.9	223.0
Elbow Extension, 112.5 d	15	133.6	43.2	57.7	75.3	131.4	149.4	241.2
Elbow Extension, 135 deg	15	125.9	46.1	67.2	75.7	122.6	157.0	247.1
Elbow Extension, 157.5 d	15	83.5	32.8	31.7	37.3	83.6	106.0	162.5
Elbow Flexion, 67.5 deg	15	59.8	32.1	29.9	33.0	42.9	88.2	129.6
Elbow Flexion, 90 deg	15	84.9	28.2	37.3	67.2	71.1	113.5	137.8
Elbow Flexion, 112.5 deg	15	108.3	25.3	67.6	72.5	104.3	134.2	153.0
Elbow Flexion, 135 deg	15	120.8	36.4	62.1	69.0	121.3	156.9	181.1
Elbow Flexion, 157.5 deg	15	94.9	33.1	46.2	59.4	90.9	123.7	172.0
Elbow Flexion, 180 deg	15	79.8	29.6	46.3	49.0	75.9	90.8	150.5

Elbow Strength Statistics  
(5.5 - 6.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	23	82.4	21.9	37.8	63.3	79.7	102.7	130.5
Elbow Extension, 90 deg	23	108.2	30.5	59.6	80.5	100.4	135.1	195.6
Elbow Extension, 112.5 deg	23	138.1	48.3	64.2	88.1	134.0	175.4	271.5
Elbow Extension, 135 deg	23	135.7	54.0	55.7	78.8	126.2	179.8	272.1
Elbow Extension, 157.5 deg	23	99.5	44.0	35.0	53.0	82.8	143.2	194.6
Elbow Flexion, 67.5 deg	23	82.3	25.2	29.3	53.3	86.8	100.9	143.5
Elbow Flexion, 90 deg	23	113.1	29.6	57.3	83.2	111.5	141.8	165.9
Elbow Flexion, 112.5 deg	23	137.0	33.0	91.1	101.1	131.8	165.6	209.1
Elbow Flexion, 135 deg	23	134.3	40.8	34.7	107.0	128.0	172.3	220.6
Elbow Flexion, 157.5 deg	23	116.0	34.0	61.7	78.1	105.3	142.6	198.0
Elbow Flexion, 180 deg	23	84.0	20.1	45.7	64.4	81.3	98.0	138.5

Elbow Strength Statistics  
(6.5 - 7.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	13	93.9	37.8	33.3	49.3	82.9	130.6	154.0
Elbow Extension, 90 deg	13	121.2	34.2	51.3	85.6	114.9	154.4	172.8
Elbow Extension, 112.5 deg	13	176.3	57.2	97.6	109.5	163.5	244.0	267.6
Elbow Extension, 135 deg	13	160.3	60.0	28.8	100.8	157.9	219.1	232.5
Elbow Extension, 157.5 deg	13	130.0	63.9	34.1	51.5	110.5	199.2	246.0
Elbow Flexion, 67.5 deg	13	108.7	30.0	56.8	67.1	109.3	131.2	169.7
Elbow Flexion, 90 deg	13	135.2	34.9	79.0	103.9	128.1	157.8	198.6
Elbow Flexion, 112.5 deg	13	158.4	51.8	70.0	95.2	146.6	214.6	266.7
Elbow Flexion, 135 deg	13	158.3	62.3	56.4	70.6	157.9	180.9	303.4
Elbow Flexion, 157.5 deg	13	134.8	51.3	48.4	81.8	129.1	161.0	256.6
Elbow Flexion, 180 deg	13	96.9	38.9	41.5	53.0	86.9	140.5	172.6

Elbow Strength Statistics  
(7.5 - 8.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	15	123.7	29.6	76.9	93.0	115.6	150.3	172.4
Elbow Extension, 90 deg	15	149.2	39.8	89.9	95.3	147.6	174.1	248.9
Elbow Extension, 112.5 d	15	208.8	58.7	107.5	147.7	184.6	254.7	330.6
Elbow Extension, 135 deg	15	193.7	68.2	110.2	123.8	175.2	287.1	309.0
Elbow Extension, 157.5 d	15	145.4	65.3	32.0	80.4	133.5	210.7	277.0
Elbow Flexion, 67.5 deg	15	145.5	39.5	84.8	100.8	135.1	188.7	230.9
Elbow Flexion, 90 deg	15	172.5	48.4	115.3	127.7	149.7	219.8	284.7
Elbow Flexion, 112.5 deg	15	203.1	56.3	149.7	154.6	188.3	243.4	363.2
Elbow Flexion, 135 deg	15	181.1	57.7	104.2	131.5	157.1	249.6	301.3
Elbow Flexion, 157.5 deg	15	164.1	58.4	101.3	108.3	132.5	225.3	287.9
Elbow Flexion, 180 deg	15	119.3	45.9	44.8	63.8	118.4	164.5	210.6

Elbow Strength Statistics  
(8.5 - 9.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	14	140.5	43.1	72.1	92.2	129.6	181.2	223.2
Elbow Extension, 90 deg	14	169.1	50.6	99.5	115.1	158.1	215.3	271.9
Elbow Extension, 112.5 deg	14	231.1	55.6	144.6	163.2	209.2	295.3	318.2
Elbow Extension, 135 deg	14	263.2	66.1	133.8	179.7	253.7	332.5	361.7
Elbow Extension, 157.5 deg	14	206.8	85.5	77.2	90.7	201.1	297.7	335.9
Elbow Flexion, 67.5 deg	14	161.5	36.9	94.5	123.7	157.5	195.7	229.9
Elbow Flexion, 90 deg	14	189.8	39.2	118.5	149.6	184.8	215.8	275.1
Elbow Flexion, 112.5 deg	14	220.9	57.5	116.7	166.3	216.5	234.3	338.5
Elbow Flexion, 135 deg	14	218.6	52.7	163.2	164.9	199.1	290.1	318.4
Elbow Flexion, 157.5 deg	14	187.9	50.1	123.2	130.7	182.1	216.3	286.9
Elbow Flexion, 180 deg	14	153.5	61.1	57.2	94.0	126.8	220.6	254.2

Elbow Strength Statistics  
(9.5 - 10.5 years)

Measurement	Descriptive Statistics							
	N	Mean	s.d.	Min	15th	50th	85th	Max
Elbow Extension, 67.5 deg	8	158.3	62.3	91.4	95.0	137.0	208.6	278.3
Elbow Extension, 90 deg	8	191.1	96.4	75.2	80.8	143.7	276.6	351.5
Elbow Extension, 112.5 deg	8	245.1	92.6	130.0	133.2	231.8	335.4	374.7
Elbow Extension, 135 deg	8	276.9	136.9	118.8	128.1	188.9	418.6	488.1
Elbow Extension, 157.5 deg	8	278.5	149.8	79.5	92.7	205.4	418.8	462.9
Elbow Flexion, 67.5 deg	8	175.2	42.7	90.4	101.6	180.5	208.3	226.5
Elbow Flexion, 90 deg	8	237.5	36.7	195.6	197.4	219.7	265.5	305.1
Elbow Flexion, 112.5 deg	8	312.8	74.0	209.3	213.8	291.7	386.0	415.4
Elbow Flexion, 135 deg	8	295.7	71.7	190.0	191.3	319.2	342.4	383.5
Elbow Flexion, 157.5 deg	8	268.6	78.0	143.0	150.6	273.7	316.2	387.4
Elbow Flexion, 180 deg	8	202.7	53.8	113.2	119.5	206.0	235.1	286.1



### 3.5 Discussion

THREE POINT PINCH: In general, the strength value obtained for three point pinch increases for older children. This is seen on the scatter plots as a gentle upwards slope towards the right. Notice that the standard deviation is also larger for older children. This trend of increased variance for larger values was seen in the previous strength study and has been seen in most reports in the literature. As children grow larger, Height, weight and most physical dimensions also exhibit a similar increase in the standard deviation.

The location of the force vector is approximately constant but decreases in magnitude as the span between gripping surfaces is increased. The location of this force vector passes through the tip of the index finger, for small spans. This suggests that the index finger is doing a larger portion of the work, at least for smaller spans.

For three point pinch, the angle formed by the force vector with the center line of the transducer becomes smaller for older children. This change probably relates to the increased precision with which an older child can control his movements.

The number of children performing a three point pinch is progressively less for 7 cm., 8 cm. and 9 cm.

This reduction in numbers is caused by the inability of smaller children to reach the larger spans. The same reduction in numbers is also seen for five point pinch and squeeze, for the same reason.

The first graph of section 3.3.3 (page 200) summarizes the results for three point pinch. The data at each span is pooled into three age groups and a mean value computed for each interval. The means have been connected with straight lines to show how strength changes for different sized objects. The oldest age group exhibits somewhat greater strength for the smallest dimension of 2 cm. than for 3-5 cm. This may be due to the better mechanical advantage afforded by a larger hand size.

**FIVE POINT PINCH:** The results for five point pinch are very similar to those for three point pinch. The actual strength value is greater for five point pinch than for the corresponding three point pinch, but the increase is modest.

The same trends are present for the location of the force vector as were seen with three point pinch. The angle formed by the force vector with the center line of the transducer may be either positive or negative, but is smaller in average magnitude than for three point pinch.

The second graph of section 3.3.3 (page 201)



summarizes the results for five point pinch. The lines are again constructed to connect the mean value of data, subdivided into three age groups. For both of the older age groups, the minimum strength value does not appear at the smallest span of 2 cm. The largest value for each age group does appear at the largest span tested, and this was usually the largest size object that a child could successfully pinch.

SQUEEZE: The strength value for squeeze also shows an upward trend with age, and in general, is larger than the two types of pinch. The distribution of points on the scatter plots suggest a more linear change with age than was found for three and five point pinch. The significance of the location of the force vector is less clear, but it does indicate the approximate position of the hand on the transducer.

The third graph of section 3.3.3 (page 202) summarizes the data for squeeze by subdivision into three age groups. Several trends are evident on these curves. The maximum strength value for each group occurs at a grip separation of three to five centimeters. The maximum strength is found with larger grip dimensions for older children. The maximum strength occurs on a rather flat region of the curves, but it is apparent that performance falls at both extremes.

There is a large decrease in strength for small objects such as the two centimeter span. The curves are approximately evenly spaced and similarly shaped.

**CORRELATION:** Tables of correlation for pinch and squeeze are presented in Section 3.3.4 (pages 211,212,213). The Pearsonian correlation coefficients are reported for selected variables. The values obtained, show a strong correlation with height for three point pinch, five point pinch, and squeeze. The magnitude of the correlation coefficients decrease for the two largest spans, but the number of subjects is reduced also. Since this reduction in number always eliminates smaller children who cannot reach the larger spans, it alters the distribution by age and all age related variables. The main utility of the correlation tables is to suggest a relative ordering of physical dimensions in their relationship to strength. The relative ordering seems remarkably constant across the pinch tables.

**ELBOW FLEXION AND EXTENSION:** The data for elbow flexion and extension were obtained on a subpopulation of approximately one hundred children; therefore the number of tests in each age interval is much smaller than for the hand tests. Accordingly, the number of points seen on the scatter plots is less.

As with other strength tests, the measured values are larger for the older children. There is an increase in the strength standard deviation as the mean value increases.

One of the more surprising findings in this study, is that smaller children appear to be stronger for elbow extension than for elbow flexion. By age ten years, the strength for flexion is greater than extension. The differences between age groups may be explained on the basis of differing lever arms at different ages, so that the mechanical advantage is different.

The data for elbow flexion and extension is summarized in Section 3.4.3 (pages 232-239). As before, the subjects are subdivided into three age groups, and the average strength value in each age group is plotted against the elbow angle. The maximum value of strength occurs near  $112.5^{\circ}$  for flexion and for younger children performing extension. The oldest age group has maximum strength near  $135^{\circ}$ .

Scatter plots are presented for elbow flexion and extension against several related variables. In each case, a trend line, fitted by least square methods, is shown with the data. Notice that the trend lines are more horizontal for flexion than for extension.

The statistics grouped by age are also presented.

### 3.6 Sample of Strength Calculations

Suppose it is desired to estimate the force which could be produced by an "average" (50th percentile) 6 year old male who is pulling upward on a knob situated in the center of a horizontal, circular surface having a 30 cm. radius. The surface is situated at waist level for the child and the knob is large enough to allow easy grasp in the right hand.

One can observe that the linkages used correspond to the sum of the radial and carpal lengths and from the table for combined sexes ---

$$\begin{aligned}L &= \text{Linkage Length} \\ &= L_R + L_C \\ &= 15.2 \text{ cm.} + 5.1 \text{ cm.} \\ &= 20.3 \text{ cm.}\end{aligned}$$

consider first the force which would be produced if the waist is held fixed so that the torque of elbow flexion is exerted at a lever arm of 20.3 cm.

$$F = \text{Force} = \frac{\text{Torque}}{\text{Linkage}}$$

For a 50th percentile child the torque is found to be 111.5 Kgf-cm thus

$$F = \frac{(111.5 \text{ Kgf-cm}) (2.2046 \text{ LB/Kgf})}{20.6 \text{ cm}} = 12.1 \text{ LBF}$$

Now consider the torque capability in the desired direction at the wrist. That is, the torque produced by wrist adduction is 22.9 Kgf-cm for 6 year old child. (See reference 162.)

$$\begin{aligned}F &= \frac{T}{D} = \frac{(22.9 \text{ Kgf-cm}) (2.2046 \text{ LB/Kgf})}{5.1 \text{ cm}} \\ &= \frac{50.5 \text{ cm-LBS}}{(5.1 \text{ cm})} = 9.89 \text{ LBS Force}\end{aligned}$$

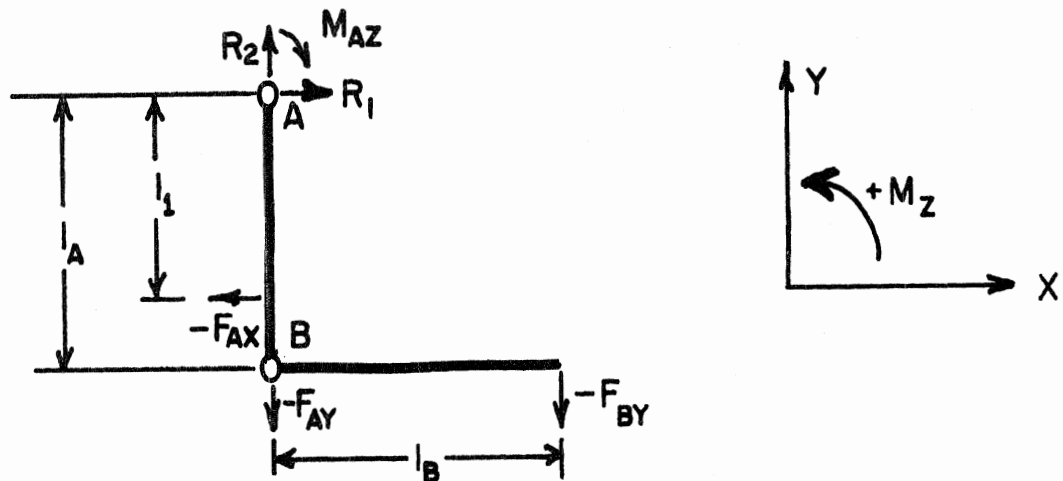
Thus, the wrist adduction capacity imposes a limit on the desired force and one would conclude that the desired force on the knob would be 9.89 pounds force.

#### 4.1. STATIC ANALYSIS OF STRENGTH CHAIR

NOTE: Refer to the limb and limb fixture shown in Figure 4.1.1.

The sum of the moments about any point on a body in static equilibrium must equal zero. A free body diagram of the limb can be drawn showing all the forces acting on the limb (excluding gravitational effects):

Note:  $F_{AX} \equiv$  force on A in the X direction, etc.



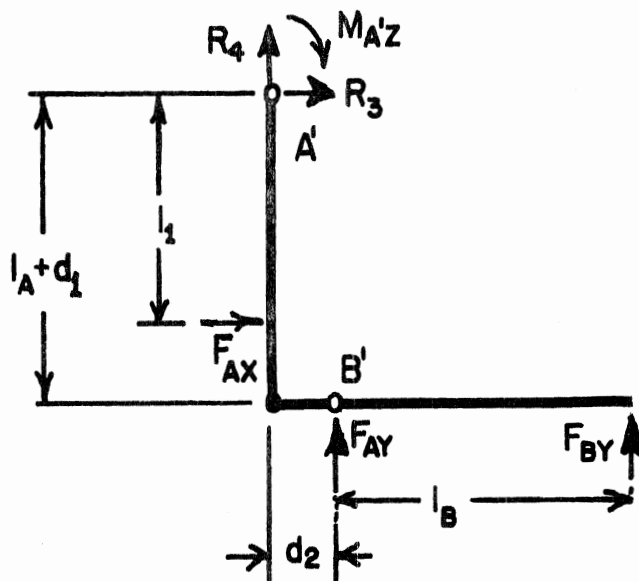
Summing the moments about joint A:

$$\Sigma M_{AZ} = -(-F_{AX} l_1) - (-F_{BY} l_B) - M_{AZ} = 0$$

$$M_{AZ} = F_{AX} l_1 + F_{BY} l_B$$

Equation #1

Similarly, a free body diagram of the limb fixture can be drawn:



Summing the moments about point A':

$$\Sigma M_{A'Z} = F_{AX}\ell_1 + F_{BY}(\ell_B + d_2) + F_{AY}d_2 - M_{A'Z} = 0$$

$$M_{A'Z} = F_{AX}\ell_1 + F_{BY}\ell_B + (F_{AY} + F_{BY})d_2 \quad \text{Equation \#2}$$

Solving Equations #1 and #2 simultaneously

$$M_{AZ} = M_{A'Z} - F_{AY}d_2 - F_{BY}d_2 \quad \text{Equation \#3}$$

Since  $M_{A'Z}$  is the bending moment to which gage set A will respond and  $M_{AZ}$  is the "strength" about joint A, the strain gage set at A provides an adequate measure of the torque generated about joint A providing the error terms  $F_{AY}d_2$  and  $F_{BY}d_2$  are small or can be approximated by either of the following methods:

- 1) By design  $d_2 \ll \ell_B$  and the approximation may be made

$$F_{BY}\ell_B \gg F_{BY}d_2 \approx 0 \quad \text{and Equation \#3 becomes}$$

$$M_{AZ} = M_{A'Z} - F_{BY}d_2 \quad \text{Equation \#4}$$

- 2)  $F_{BX}$  may be measured by the gage set at B' where

$$M_{BZ} = M_{B'Z} \quad \text{exactly and} \quad F_{BY} = \frac{M_{B'Z}}{\ell_B}$$

Substituting this relation into Equation #4 gives

$$M_{AZ} = M_{A'Z} - M_{B'Z} \frac{d_2}{\ell_B} \quad \text{Equation \#5}$$

Where:  $M_{A'Z}$  = output of gage set A

$M_{B'Z}$  = output of gage set B

$\ell_B$  = known linkage measurement

$d_2$  = known constant

Method (2) is conveniently used since the secondary channels were sampled specifically to provide the required additional data, i.e., the simultaneous torque about the more distal joints. For the hip and shoulder joints, a cascaded error term is generated.

Sampling the more distal joints allows for precise calculation of the error terms.

Finally, it should be noted that these error terms arise only when the axis of rotation does not pass through the gage set used for measurement. It is implied that when a gage set does not align with the axis in one plane, it does in a perpendicular plane and no error term exists for strength measurement in that perpendicular plane. This general example was chosen to exemplify error terms which generally arise only in sagittal plane strength measurements (by chair design).

## 4.2 Principle of Operation of Grip Strength Transducer

In the plane of its handle, the grip strength transducer may be represented schematically as a bar of constant crosssection shaped like the letter "G". The child forces the two handles together where indicated by exerting shear and normal forces  $F_s$  and  $F_n$ , respectively. Resistance strain gages are located at positions  $A_1$ ,  $A_2$ ,  $B_1$ ,  $B_2$ , and C and respond to bending moments on the bar at these locations.

Severing the bar at each gage set and writing static equations of equilibrium of moments for the distal handle: (Note:  $M_{A1}$  = bend moment at gage set  $A_1$ )

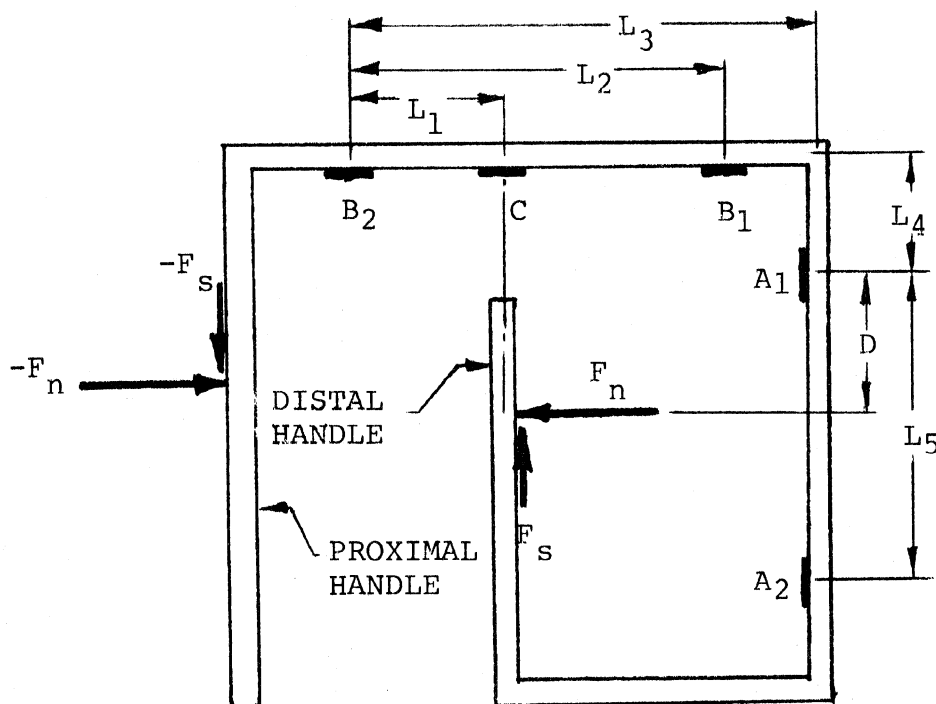
$$\text{At } A_1: \quad (1) \quad M_{A1} = -F_n (D) - F_s (L_3 - L_1)$$

$$\text{At } A_2: \quad (2) \quad M_{A2} = +F_n (L_5 - D) - F_s (L_3 - L_1)$$

$$\text{At } B_1: \quad (3) \quad M_{B1} = -F_n (L_4 + D) - F_s (L_2 - L_1)$$

$$\text{At } B_2: \quad (4) \quad M_{B2} = -F_n (L_4 + D) + F_s (L_1)$$

$$\text{At } C: \quad (5) \quad M_C = -F_n (L_4 + D)$$





Subtracting equation (2) from equation (1):

$$(6) \quad M_{A2} - M_{A1} = F_n L_5$$

Subtracting equation (4) from equation (3):

$$(7) \quad M_{B2} - M_{B1} = F_s L_2$$

In the appropriate wheatstone bridge configuration, the difference in strain gage outputs at two different bar locations may be obtained providing the cross sectional material and geometry at each position is identical:

Thus,

$$(8) \quad \Delta M_A = M_{A2} - M_{A1} (=F_n L_5)$$

$$(9) \quad \Delta M_B = M_{B2} - M_{B1} (=F_s L_2)$$

are measured independent quantities requiring 2 channels of data.

Next, substituting equation (8) into (5) and rewriting:

$$(10) \quad (L_4 + D) = - \frac{M_C L_5}{\Delta M_A}$$

Therefore, utilizing a third gage set input  $M_C$ , one can determine  $F_n$ ,  $F_s$ , and  $L_F (=L_4 + D)$  by equations (8), (9), and (10):

$F_n = \frac{\Delta M_A}{L_5}$	$L_F = \frac{-M_C L_5}{\Delta M_A}$
$F_s = \frac{\Delta M_B}{L_2}$	

Additionally, a resultant force on the handle may be determined as well as its direction ( $\theta$ ) perpendicular to the handle:

$$F = \sqrt{(F_n)^2 + (F_s)^2}$$
$$\theta = \tan^{-1} \frac{F_s}{F_n}$$

Finally, it should be noted that determination of  $L_F$  requires a  $F_n$  component to generate  $M_C$  and  $M_A$ . In power grip configuration,  $F_n$  is the major force component and no difficulty is encountered.

Generally  $F_n \gg F_s$  ( $\theta < 20^\circ$ ).

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