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AN ANNOTATED BIBLIOGRAPHY OF UNITED STATES AIR FORCE APPLIED PHYSICAL ANTHROPOLOGY

JANUARY 1946 TO MARCH 1972

COMPILED BY RENA KIMBROUGH

MARCH 1972

AEROSPACE MEDICAL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

60

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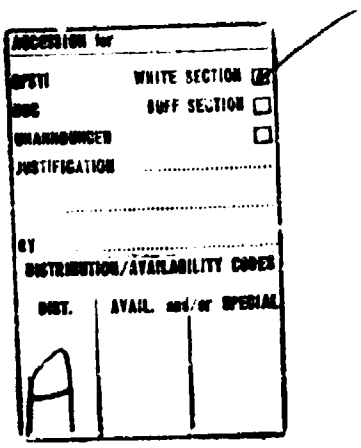

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13. ABSTRACT

This report contains the titles, authors, publication/source information, and the abstracts of 122 technical reports and articles published by Anthropology Branch of the Aerospace Medical Research Laboratory between January 1946 and March 1972. It is a detailed document of the scope of the effort of the Air Force in the field of applied physical anthropology to provide the information on human body size and biomechanical characteristics of Air Force personnel required for the development and evaluation of Air Force systems, personal-protective equipment and clothing. Work in the following areas is described:

Anthropometry
- Air Force men and women
- Foreign military populations
- Comparative
- Techniques

Workspace
- Aircraft stations
- Ground stations
- Controls

Biomechanics
- Muscle strength
- Mobility
- Mass distribution

Sizing and designing of personal equipment
- Body supports
- Comfort
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Cockpit geometry						
Comfort						
Controls						
Engineering anthropometry						
Fit-tests						
Helmets						
Lifting, pushing, pulling						
Man models						
Mass distribution (humans)						
Mobility						
Muscle strength						
Oxygen masks						
Personal-protective equipment						
Physical anthropology						
Pressure suits						
Range of motion						
Reach capability						
Seat design						
Sizing systems (garments)						
Somatotyping						
Workstation design						

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ADDENDUM SHEET

Title	Authors	Report Number and Date
Anthropology and Space Research	Hertzberg	Published in Anthropology in the Armed Services: Research in Environment, Physique, and Social Organization, L. Dupree (Editor), 1958.

ABSTRACT: This paper discusses the contributions of engineering anthropology in space exploration, pointing out that the brilliant advances into outer space 500 miles up are based on the anthropological developments in oxygen masks, in pressure suits, gloves and helmets, and in other protective equipment. The problem of human survival in an environment offering no oxygen, no water, no atmospheric pressure and no gravity is considered, with a discussion of the means of work output in such conditions. Suggestions are made for preliminary ground research on those problems, which would enlist the aid of academic as well as military anthropologists.

Title	Authors	Report Number and Date
Principles of Cockpit Seating	Patt & Randall	TSEAA-695-58C January 1946 AD 50569

ABSTRACT: This report presents a study of seating requirements for the pilot position in military aircraft. It is one of a series committed to the determination of the fundamental seat and position requirements of flying personnel in the various crew positions in military aircraft. Ninety-five bomber pilots were used as subjects in these experiments. The fundamental requirements of pilot seating in aircraft were determined and were found to be dependent upon cockpit level (vertical distance from horizontal line of vision to level of heel rest) and the type of manual control mechanism used (wheel or stick). Comfort requirements have been determined to be dependent upon the same factors, and also upon seat angulation, differential support of the body over the seat contour and the positioning of the rudder pedals and control column with respect to the seat.

Title	Authors	Report Number and Date
Human Body Size in Military Aircraft and Personal Equipment	Randall, Damon, Benton & Patt	AAF TR 5501, June 1946 (Reprinted 1963) ATI 25419

ABSTRACT: This report deals with the relation of human body size to military aircraft and equipment. It contains the necessary data and instructional material to guide the designers of aircraft and associated flying equipment in the proper use of anthropometry, as it applies to AAF flying personnel. The functional man is fully described and the spatial requirements of his personal equipment are evaluated. Finally, the complete functional man is considered in his air crew position and as an integral part of the functional aircraft.

Title	Authors	Report Number and Date
Angular Fields of View Through the A-1 Gunsight in the P-80 Cockpit Modified for Ejection	Hertzberg	TSEAA-695-73 December 1946 Not Available from DDC

ABSTRACT: This report presents the results of a study of the angular field of view in the P-80 cockpit at specified eye-to-pivot distances. Installation of the ejection seat in this aircraft forced the lengthening of cockpits. As a step in providing optimal gun sight placement, the

Armament Laboratory requested a study of the angular fields of view available to the pilot at specified eye-to-sight pivot distances 30, 35, 40, 45, and 50 inches.

Four representative pilots wearing standard equipment were employed in measuring the angular fields of view. Their average angular fields of view were found to range from 10, 2° vertically and 22° laterally at the 30-inch distance. The only important factors limiting the field of view were the width of cockpit and canopy, and the size of the crash helmet. Other variables such as personal equipment and body size were found to be of no importance in limiting their fields.

Title	Authors	Report Number and Date
Contoured Seat for the Top of an Experimental Rigid Dinghy Box	Hertzberg	TSEAA-670-9, May 1947 ATI 139 061

ABSTRACT: The purpose of this paper is to report the adaptation of the rigid dinghy box to contoured seating purposes, and to present metric data on the actual seating surface recommended. This contoured seat should provide the average pilot with both a high degree of seat comfort and with a reasonable ability to extend his legs without undue discomfort. Although several sizes of contoured seats would be necessary to fit all Air Force personnel, the experimental average size described should adequately support the great majority of pilots.

Title	Authors	Report Number and Date
A Prone Position Bed for Pilots	Hertzberg & Colgan	MCREXD-695-71D June 1948, ATI 34088

ABSTRACT: This report describes the development of a prone position bed for pilots, and the results of comfort tests thereof. This bed consists of specially-shaped sides to which a length of nylon netting is affixed. Special controls, foot rests, net tension adjusting cams for abdominal support, chin rest and head support are required as adjuncts to the bed proper. Comfort tests of the bed were conducted with a series of 19 subjects who represented over 95% of USAF personnel in both stature and weight. The bed was adjusted to each subject for utmost comfort. The major adjustments were for stature, abdominal support and for arm position on the controls.

Eighteen subjects lay on the prone position bed for 8 consecutive hours each, or longer, and one subject lay 4 hours. After formal tests were completed, two members of the test team lay on the bed for 12 hours each.

Title	Authors	Report Number and Date
Post War Anthropometry in the Air Force	Hertzberg	Am. Jour. Phys. Anthrop. 6:3, 363-371, Sept 1948

ABSTRACT: A resume of activities current in 1948 in the Anthropology Branch.

Title	Authors	Report Number and Date
Inhabited Wing Tip Turret	Hertzberg	MCREXD-695-80 November 1948

ABSTRACT: Purpose of this report was to describe some subjective impressions and objective measurements observed during flight in the inhabited turret installed on the right wing of a B-17 aircraft (a project sponsored by Armament Laboratory). Eight representatives of the Aero Medical Laboratory flew in this turret. Their opinions were unanimous regarding the following subject sensations:

a. The location was livable and comfortable from the physiological standpoint, with no sense of nausea or uneasiness from the most violent maneuvers.

b. Visibility was greatly superior to that of any other situation.

Measurements showed that the highest vertical accelerations the pilot could produce in the wing tip turret by means of the most violent maneuvers were of the order of only plus 4g, while ordinary maneuvers produced only plus 2g. In landing, an instantaneous value of plus 8g was recorded. These forces, however, are not unique to the wing tip position and are easily tolerable.

Certain minor sources of discomfort were found including high noise level which interfered considerably with intercommunication, and also high temperatures during taxiing in the hot summer sun. Ventilation and temperature were satisfactory during flight.

Title	Authors	Report Number and Date
Comfort Tests of the Pulsating Seat Cushion and Lumbar Pad	Hertzberg	MCREXD-695-82 April 1949, AD 70599

ABSTRACT: The tests were conducted using 21 subjects who represented approximately 88% of Air Force personnel in weight and 95% in stature. The period of sitting varied from 4 hours, 55 minutes to

8 hours, with an average of 6 hours, 45 minutes. One group of subjects sat on the non-pulsating cushion an average of 2 hours, 40 minutes before starting the pulsations. The second group had the cushion pulsating through the test. Apparently the latter group was able to sit somewhat longer under these conditions--approximately 4 hours on the average--before reaching the peak of discomfort, although this cannot be considered definitely established. Subjects periodically expressed their degree of discomfort on a five step scale ("absent, mild, moderate, severe, unbearable").

Test results indicate that this cushion does help to relieve buttock discomfort, but does not eliminate it.

Title	Authors	Report Number and Date
Contoured Seat for the Top of an Experimental Rigid Dinghy Box Report No. 2	Hertzberg	MCREXD-670-9D June 1949, ATI 67990

ABSTRACT: Purpose of this report is to describe some changes in the contour of the original rigid seating surface. These changes were aimed at increasing comfort and reducing the possibility of injury during ejection. Changes consisted of including a groove for the coccyx, moving the position of the lowest point of the seat 1 1/2 inches rearward, and increasing the curvature of certain contour lines. The latter two changes were recommended in order to keep the buttocks more nearly in line with the spinal column during ejection.

Title	Authors	Report Number and Date
Hammock for the B-36 Airplane	Hertzberg & Daniels	MCREXD-720-143 October 1949, ATI 122733

ABSTRACT: This report describes a rapidly demountable net sleeping hammock for intermittant use by the stand-by crew in the forward compartment of the B-36 airplane.

Title	Authors	Report Number and Date
The Center of Gravity of a Fully-Loaded F-86 Ejection Seat in the Ejection Position	Hertzberg & Daniels	MCREXD-45341-4-5 March 1950, ATI 74410

ABSTRACT: Purpose of the study was to determine the center of gravity of the F-86 Ejection Seat in ejection position when loaded with a

pilot wearing full flying equipment. The c.g. of the seat was measured by suspension in two positions under full load. It was shown that the c.g. varies for each individual according to size, weight, and body build, and also for the position of the subject on the seat. Thus the c.g. of an individual may be thought of as an area rather than a point. The average c.g. of nine subjects was located at a point 13 3/16 inches from the back of the seat and 15 7/8 inches from the bottom of the seat pan. For the lighter than average men in this series the average c.g. was located approximately 1/4 inch aft and 1/4 inch below that point. The c.g. of the loaded seat thus travels roughly 7/8 inch along a line whose angle is approximately 30° from the seat pan.

Title	Authors	Report Number and Date
Air Force Anthropology in 1950	Hertzberg & Daniels	Am. Jour. Phys. Anthrop. 10:2, 201-208, June 1952

ABSTRACT: This paper presents an account of research underway, emphasizing its breadth and diversity.

Title	Authors	Report Number and Date
Applied Anthropometry of the Hand	Daniels & Hertzberg	Am. Jour. Phys. Anthrop. 10:2, 209-215, June 1952

ABSTRACT: This paper describes briefly the development of the stick grip used in controlling aircraft, and the research on hand shape that underlies a new design of stick grip.

Title	Authors	Report Number and Date
Review of Escape Hatch Sizes for Bailout and Ditching	White, Johnson & Hertzberg	WADC TN 52-81 September 1952 AD 99784

ABSTRACT: The purpose of this study was to review war time specifications of escape hatches in terms of current and experimental flying equipment. Seven subjects ranging in height, weight, and shoulder width from the 5th percentile to the 95th percentile of Air Force flying personnel (1950 Survey) were used in most of these tests. Three combinations of clothing and equipment were involved. The mock-up for the tests consisted of a plywood panel having slats. The panel could be positioned in the horizontal, vertical or any intermediate plane to simulate an escape hatch in any portion of the aircraft, while the opening could be adjusted to any desirable size from 17 inches to 36 inches square. These tests demonstrated that the present standard sizes of 20 by 31 inches

for the side hatch and 20 by 29 inches for the bottom hatch were adequate for use with either the current equipment or the newer experimental clothing providing no tunnel is involved, or the access area is not obstructed. Furthermore, the standard size of the top hatch should be increased to 22 by 22 inches and there should be a step or ledge not more than 45 inches below the lowest edge of the hatch to give additional leverage to shorter crew members.

Title	Authors	Report Number and Date
The "Average Man"?	Daniels	TN WCRD 53-7 December 1952, AD 10203

ABSTRACT: The tendency to think in terms of the "average man" is a pitfall into which many persons blunder when attempting to apply human body size data to design problems. Actually it is virtually impossible to find an "average man" in the Air Force population. This is not because of any unique traits of this group of men, but because of the great variability of body dimensions which is characteristic to all men. It is the intent of this Technical Note to point out and explain some of the factors that lead to the difficulties arising from the use of "average" dimensions and to indicate to some extent how they may be avoided.

The data on which this Technical Note is based are the results of the Air Force Anthropometric Survey of 1950. There is, however, every reason to suppose that conclusions similar to those reported here would have been reached if the same type of analysis had been applied to body size data based on almost any group of people.

Title	Authors	Report Number and Date
Development of a Workspace Measuring Device	Dempsey	WADC TR 53-53 March 1953, AD 13206

ABSTRACT: This technical report describes a Workspace Measuring Device which was developed to determine the maximum, minimum and optimum space requirements of Air Force pilots when seated in the cockpit situation; and to simulate in the Laboratory existing or proposed cockpit designs with an eye to proper space utilization.

Title	Authors	Report Number and Date
Nomographs of Head Measurements	Churchill & Daniels	WADC TR 53-14 May 1953, AD 16748

ABSTRACT: To achieve the optimum design of equipment intended to fit the wearer's head closely, a knowledge of the interrelationships between the more important head dimensions is necessary.

This report provides such information in the form of two nomographs for determining the most accurate estimate for each of twelve head dimensions based on known values of head length and head breadth, and head breadth and head circumference.

Title	Authors	Report Number and Date
Anthropometry of WAF Basic Trainees	Daniels, Myers & Worrall	WADC TR 53-12 July 1953, AD 20542

ABSTRACT: Body size data for 63 dimensions of 852 Women's Air Force basic trainees are presented for use by the designers of Air Force equipment.

The statistics reported for each measurement include the mean, standard deviation, coefficient of variation, standard errors of these statistics, range and selected percentiles from the first to the ninety-ninth. In general, these statistics are reported in both the metric and English values.

A complete description of the anthropometric techniques used is presented.

Title	Authors	Report Number and Date
Anthropometry of Male Basic Trainees	Daniels, Myers & Churchill	WADC TR 53-49 July 1953, AD 20717

ABSTRACT: Body size data for 60 measurements of over 3,000 Air Force male basic trainees are presented for use by aircraft and equipment designers.

The statistics reported for each measurement are: the mean, standard deviation, coefficient of variation, standard errors of these statistics, range, and selected percentiles from the first to the ninety-ninth. In general, the statistics are reported in both the metric and English values.

A complete description of the anthropometric techniques used is presented.

Title	Authors	Report Number and Date
Ground Study of the Non-ejection Methods of Escape From B-47B Aircraft	Morrison & Schafer	WADC TR 54-6 April 1954, AD 30282

ABSTRACT: This report covers Phase 1, a Ground Study of the non-ejection methods of escape from B-47B aircraft. Because the cabin space available to the crew members is so limited, it was necessary to make a thorough investigation of those body positions and movements at the disposal of the crew when evacuating the aircraft. This study, done at the Wright-Patterson Air Force Base, led to the establishment of optimum procedures to be followed by each man when leaving his station and reaching the possible escape exits, and the most feasible body positions for leaving the aircraft.

The personal equipment worn by each subject during these tests included both winter and summer flying clothing. Each procedure was performed with and without the A-1 survival kit.

Time studies covered crew escape through the ventral hatch, with and without the use of an escape bracket, and through the crawlway to the bomb bay. Eight crews participated in the ventral hatch tests and six crews in the bomb bay tests. Ground studies of egress through the navigator's ditching hatch and canopy were limited to the timing of individuals making personal leads disconnects and standing at their stations. The feasibility of using these exits will have to be determined during the Air Study Phase.

Analysis of the data thus accumulated indicates that the optimum method of nonejection escape from this aircraft is through the central hatch in a feet-first, facing-aft position utilizing the Barto escape bracket. It must be stressed that the data are based on the tests made with the aircraft on the ground and in the absence of factors that would cause a flight emergency necessitating bailout.

Title	Authors	Report Number and Date
Anthropometry of Flying Personnel - 1950	Hertzberg, Daniels & Churchill	WADC TR 52-321 September 1954 AD 47953

ABSTRACT: Body size data for 132 measurements of over 4,000 Air Force flying personnel are presented. Organization of the survey is briefly discussed and the techniques of measurement are illustrated by photographs for the benefit of other anthropologists. Both diametral and surface measurements are included. Dimensions are given in both centimeters and inches.

A description of the statistics and an explanation of their use are given with some discussion of certain statistical shortcuts employed in the reduction of the data. The tabulations include range, mean, standard deviation, coefficient of variation, and twenty-five selected values from the first to the ninety-ninth percentile. Means and standard deviation

values for each dimension are also given for nine subgroups based on flight duties.

A Glossary and Bibliography are included.

These data are presented for use by the designers of aircraft, clothing and equipment.

Title	Authors	Report Number and Date
Space Requirements of the Seated Operator	Dempster	WADC TR 55-159 July 1955, AD 87892

ABSTRACT: The structure of the limb joints and the range and type of their motions were studied on cadaver material, with supplementary work on living subjects, in order to clarify geometric, kinematic and engineering aspects of the limb mechanism. Plans for the construction of manikin joints which showed normal ranges of limb movement were developed from this information. Specifications were also worked out for drafting board manikins which show correct limb ranges for seated postures. Subjects comparable to the model physique of Air Force flying personnel and highly selected small samples of muscular, thin, and rotund builds supplied information on the range of possible hand and foot movements which was consistent with the seated posture. Maximum dimensions of the work space for seated individuals were determined; a study of the kinematic factors involved permitted an evaluation of the potential utility of different regions within reach. Eight cadavers were dismembered to provide data on such physical constants as mass of parts, segment centers of gravity, density and moments of inertia. This work was supplemented by data on the distribution of body bulk in the living subjects studied. Applications of the above information to analyses of horizontal push and pull forces in terms of couples permitted an evaluation of the effectiveness of body mass, leverages and support areas.

Title	Authors	Report Number and Date
Arm Strength at Selected Degrees of Elbow Flexion	Hunsicker	WADC TR 54-548 August 1955, AD 81792

ABSTRACT: A selected summary of the strength testing literature forms the first part of this study. This is followed by a listing of the modifications that had to be made on the Kinematic Muscle Study machine as a result of exploratory testing. The major portion of the investigation is concerned with the results of testing 55 young men on 60 arm strength tests in the sitting position and 60 in the prone position. Percentile tables and figures depicting arm strength in relation to degrees

of elbow flexion are included. Recommendations for further use of the Kinematic Muscle Study machine are offered.

Title	Authors	Report Number and Date
The Anthropometry of Body Action	Dempster	Annals of the New York Acad. of Science, 63:4, 559-585, November 1955 (Also published as WADD TR 60-18, January 1960, AD 234 005.)

ABSTRACT: The author discusses the principles of investigating dynamic anthropometry in relation to movement patterns of the human body.

Title	Authors	Report Number and Date
Some Contributions of Applied Physical Anthropology to Human Engineering	Hertzberg	Annals of the New York Acad. of Science, 63:4, 616-629, November 1955 (Also published as WADD TR 60-19, January 1960, AD 233 711.)

ABSTRACT: The author defines human engineering as "fitting the machine to the man and keeping him functioning with efficiency, with safety and without discomfort, in any environment," and presents three studies as examples of the contributions that can be made by physical anthropology to human engineering. Under the first example, the author condemns the use of "average data," and summarizes the engineering use of the percentile curve as a tool to improve the sizing of workspace, clothing, or personal-protective equipment. The second example outlines the use of muscle-strength data in improving human safety and ease of machine operation. The third presents an attempt to answer the question, "What happens to the buttocks when you sit on them?" A map of the buttock sitting area is shown, with a general description of cushions designed according to theoretical and experimental findings.

Title	Authors	Report Number and Date
Bodily Dimensions of the Older Pilot	Fry & Churchill	WADC TR 56-459 June 1956, AD 97217

ABSTRACT: A comparison of 132 body dimensions on selected groups of older and younger pilots is presented. These groups are compared

on their mean values of these dimensions, and more intensively on five percentile distributions of 20 dimensions.

When differences exist between the groups, an explanation has been sought in terms of the physical process of aging, and in selection.

Most of the older-younger pilot differences are small and statistically non-significant, but a few are of great importance, and should be taken into account in designing Air Force equipment.

Title	Authors	Report Number and Date
The Anthropometry of Working Positions	Hertzberg, Emanuel & Alexander	WADC TR 54-520 August 1956, AD 110 573

ABSTRACT: A sample of forty adult males has been measured to ascertain new body size data for various representative working positions. Measurements were taken with the body in the standing, kneeling, crawling, and prone positions. Problems met in developing procedures for an anthropometry describing working positions are discussed, along with possible approaches for data gathering.

Title	Authors	Report Number and Date
A Statistical Comparison of the Body Typing Methods of Hooton and Sheldon	Dupertuis & Emanuel	WADC TR 56-366 August 1956, AD 97205

ABSTRACT: Body type component ratings made according to the standards of Hooton and Sheldon were compared in a sample of 500 Air Force flying personnel. Correlation coefficients for the two ratings of the same components are as follows: first component, .82; second component, .83; third component, .86; gynandromorphy, .66; dysplasia, .05. On the average, the Hooton ratings were .51 unit more than the Sheldon ratings for the first component, 1.00 unit less for the second component, and .67 unit more for the third component. For all three primary components identical ratings were given in 33.7% of the cases, while an absolute deviation of one unit occurred in 50.3% of the cases, a deviation of two in 15.5% of the cases, and a deviation of three units occurred in .6% of the cases. Six subjects were given identical body type ratings according to both systems. Regression equations are given for the relationships between the primary components, but the standard errors of estimate are too high to permit accurate equation of body type assessments on the same individual.

Title	Authors	Report Number and Date
A Study of Human Weight Lifting Capabilities for Loading Ammunition into the F-86H Aircraft	Emanuel, Chaffee & Wing	WADC TR 56-367 August 1956, AD 97206

ABSTRACT: The weight lifting ability of a sample of nineteen young men was studied. The lifting procedures were standardized and controlled in order to simulate a precise task, that of loading ammunition into the F-86H aircraft. An ammunition case with varying amounts of weight was lifted to platforms one, two, three, four, five, six and seven feet above the floor.

All subjects could lift the case in the prescribed fashion up to and including five feet above the floor. Only nine subjects could properly lift to six feet, and only one individual performed at the seven foot platform. Suggested maximum weights required for actual lifting tasks are presented. Based on the fifth percentile values, they are as follows: one foot - 142 pounds; two feet - 139 pounds; three feet - 77 pounds; four feet - 55 pounds; five feet - 36 pounds.

Title	Authors	Report Number and Date
A Sizing System for High Altitude Gloves	Barter & Alexander	WADC TR 56-599 December 1956 AD 110 589

ABSTRACT: This report presents the rationale for and procedures followed in the development of a sizing program for high altitude gloves. This program is based on four divisions of hand circumference, each subdivided into three divisions of hand length making a total of twelve sizes. A selected sample of 100 hands was measured to provide the thirty-one dimensions presented for design purposes. Summary statistics, regression equations, design dimensions, and a procurement tariff are presented in various tables throughout the report.

The results of a fit-test of two differing styles of gloves sized according to this program indicate that a high percentage of personnel can be fitted adequately in their indicated size. Detailed instructions for determining the indicated size of gloves are also included.

Title	Authors	Report Number and Date
Body Dimension Changes During Basic Training	Meyers, Daniels, Churchill & Roelke	WADC TR 56-458 December 1956 AD 97216

ABSTRACT: Changes during basic training in the body dimensions of approximately two hundred male and a similar number of female airmen were measured. Eight circumferences, weight, and stature were measured weekly during each of the first four weeks and during the eighth and twelfth weeks of training.

The resulting data were analyzed in the hope that changes in proper clothing size which occur during the training period could be predicted in advance. Variability in the changes was found to be too large and the relationships among the changes and the airmen's original dimensions too poor to permit useful predictions.

A complete resume of the results of the investigations are presented here for the guidance of personnel concerned with the design and the issuance of clothing for and to basic trainees.

Title	Authors	Report Number and Date
A Comfort Evaluation of a Form-Fitting High Altitude Helmet	Alexander & Hertzberg	WADC TR 56-404 February 1957 AD 110 548

ABSTRACT: This report describes comfort tests on an experimental pressure helmet assembly, consisting of an outer rigid shell and an inner compressible, form-fitting liner of polyurethane foam. Seventy-two subjects were used, of whom twenty-one were rated military pilots. A number of testing techniques and fabricational requirements for comfort and acceptability are discussed, and their applicability to most forms of headgear, especially those using compressible liner material, is indicated.

Title	Authors	Report Number and Date
Linear Distance Changes Over Body Joints	Emanuel & Barter	WADC TR 56-364 February 1957, AD 118 003

ABSTRACT: Linear distance changes over the body surface resulting from various joint movements were studied on a series of thirty young men. The following joints and joint complexes were studied: head and neck, shoulder, elbow, wrist, fingers, trunk, hip, knee, and ankle. Summary statistics and design values are presented for 48 linear distance changes measured over these joints.

While there are usually definite and significant changes in bodily dimensions resulting from joint movements, these changes are generally fairly constant in magnitude. At the same time, the changes are mostly unrelated to body size. The information is designed for application to

close-fitting altitude clothing which must provide both physiological protection and body mobility. In addition, these data can serve as a guide for determining easement factors for more commonplace types of clothing.

Title	Authors	Report Number and Date
Estimation of the Mass of Body Segments	Barter	WADC TR 57-260 April 1957, AD 118 222

ABSTRACT: The present study is concerned with the reanalysis of the data concerning the mass of body segments published in WADC TR 55-159, Space Requirements of the Seated Operator, Dempster, 1955, and in The Center of Gravity of the Human Body as Related to the Equipment of the German Infantry, Braune and Fischer, 1889.

Regression equations for computing the mass of body segments for any known body weight are presented along with data on estimated weights of body segments of Air Force flying personnel.

Title	Authors	Report Number and Date
Nomograph of the Hand and Its Related Dimensions	Churchill, Kuby & Daniels	WADC TR 57-198 April 1957, AD 118 162

ABSTRACT: The design of equipment which must fit closely a part of the users' body calls for a knowledge both of the actual dimensions of this part of the body and the interrelationships among these dimensions.

This report brings together both types of information for the hand. Dimensional data for the hands of both male and female USAF personnel are summarized in tabular and graphic form. Intensities of the interrelationships within each of the two groups of dimensions are given in the form of tables of correlation coefficients. A series of tables supply estimates of the other dimensions for the appropriate ranges of values of hand length, hand breadth at metacarpale, hand breadth at thumb, and fist circumference.

Nomographic charts are presented for estimating the related dimensions for all likely combinations of values of the hand lengths and breadths for both USAF flying personnel and WAFs.

The basic data used for the men are those obtained from a survey of USAF flying personnel; for women the data are those obtained from a survey of WAF basic trainees. Data obtained from other surveys of military personnel are summarized; these data suggest the applicability of the tables and charts presented here to the design of articles intended for almost any group of USAF personnel.

Title	Authors	Report Number and Date
WAF Trainee Body Dimensions: A Correlation Matrix	Churchill & Bernhardi	WADC TR 57-197 April 1957, AD 118 161

ABSTRACT: Correlation coefficients expressing the degree of relationship between the 1830 pairings of all WAF basic trainee body dimensions are presented in this report. Additionally over two thousand multiple correlation coefficients expressing the degree of relationship between each of these dimensions and 36 pairs of them are also given. Regression equations for estimating all other dimensions from specified values of stature, of weight, and of stature and weight together are listed. Values computed from most of these equations are tabulated for the most frequently occurring values of stature, weight, and stature-weight combinations. This correlation material supplements the basic dimensional data given in Anthropometry of WAF Basic Trainees, WADC TR 53-12, and, with these data, provides a basis for the planning and execution of design programs involving the body dimensions of these individuals.

Title	Authors	Report Number and Date
Metrical Relations Among Dimensions of the Head and Face	Churchill & Truett	WADC TR 56-621 June 1957, AD 110 629

ABSTRACT: Correlation data for the head and face dimensions of two groups of USAF personnel are presented. These data extend the useful information about these dimensions into the areas in which two or more dimensions are considered simultaneously. Forty-one dimensions of flying personnel, based on a sample of over 4,000, and six dimensions of WAF trainees, based on a sample of 852, are reported. In addition to a presentation of the data, the report discusses the utility of correlational statistics in the design of personal equipment and describes the procedures used in obtaining these data.

Coefficients of correlation for the 820 pairs of flying personnel data and the 15 pairs of WAF data are given. Multiple correlation coefficients for each dimension and selected pairs of dimensions for the flying personnel are also given. Regression equations for estimating one dimension from values of another are listed for most pairs of flying personnel dimensions which are at least moderately well correlated. About seventy bivariate frequency tables are presented.

No useful summary of this large body of statistics can be made since it is the individual data which are of importance.

Title	Authors	Report Number and Date
Height-Weight Sizing and Fit-Test of a Cutaway G-Suit, Type CSU-3/P	Emanuel & Alexander	WADC TR 57-432 July 1957, AD 130 912

ABSTRACT: Body size data from the 1950 Air Force Anthropometric Survey have been reanalyzed to yield a statistical sizing program based on height and weight. This six-size program was incorporated into the Type CSU-3/P Cutaway Anti-G Garment, which was tested from the standpoint of fit and comfort. Suit selection was accomplished simply by asking each subject his height and weight. Of seventy-three subjects fitted, seventy-two were comfortably accommodated by the size indicated by height and weight values. It is concluded that this sizing procedure will result in the saving of time and money because of the ease of fitting, reduction of individualized tailoring and simplification of procurement.

Title	Authors	Report Number and Date
A Statistical Evaluation of Joint Range Data	Barter Emanuel & Truett	WADC TN 57-311 August 1957, AD 131 028

ABSTRACT: This study reanalyzes the data concerning the range of motion of human body joints published in WADC TR 55-159, Space Requirements of the Seated Operator, by W. T. Dempster. The reanalysis is intended to present the information in a form more applicable to Air Force design problems. An analysis of variance of 43 joint movements for four subgroups originally selected on the basis of physique revealed that 12 body movements (28%) were related to physique. The subgroup statistics were combined to yield summary statistics for the total sample of 39 young men. Design ranges were derived from these total group values. Descriptions and illustrations of joint movements are included.

Title	Authors	Report Number and Date
A Study of Muscle Forces and Fatigue	Hunsicker	WADC TR 57-586 December 1957 AD 131 087

ABSTRACT: The first phase of the research deals with the strength test results taken on 30 subjects covering 120 strength tests. The subjects were seated in a simulated pilot-seat and six movements were tested. The results are presented in percentile tables and graphic form. The next part of the study involves data on 25 subjects who were

tested to determine the amount of strength possible in wrist pronation and wrist supination. The final phase of the research gives information on the strength decrement over a 42-hour period in which the subjects were tested hourly. Several recommendations are offered.

Title	Authors	Report Number and Date
Stereophotogrammetry as an Anthropometric Tool	Hertzberg, Dupertuis & Emanuel	Photogrammetric Engr. December 1957, 942-947 (Also published as WADC TR 58-67, February 1958, AD 150 964.)

ABSTRACT: This paper briefly reviews previous biological applications of stereophotogrammetry, and outlines with illustrations the present procedures used to draw human body contours at 1/2 inch intervals. It compares the dimensions derived from plotted profiles with those taken by hand of the subjects themselves. It discusses the utility of stereo data for special anthropometric purposes, and mentions further applications for other biological sciences.

Title	Authors	Report Number and Date
Annotated Bibliography of Applied Physical Anthropology in Human Engineering	Hansen, Cornog, Yoh Company, Hertzberg (Editor)	WADC TR 56-30 May 1958, AD 155 622

ABSTRACT: This volume contains condensations of 121 reports in the field of Applied Physical Anthropology. A majority of the annotations are grouped under three headings: Anthropom .try, Biomechanics and Comfort; a few are included in a general group. Working data and important illustrations are quoted directly from the original papers in most cases. A complete index is arranged by author as well as by subject. An additional list of reports (not annotated) is included as background material. Two appendices containing relevant commentary on Seating Comfort and Anthropomorphic Dummies, are also included.

Title	Authors	Report Number and Date
Anthropometric Sizing and Fit-Test of the MC-1 Oral-Nasal Oxygen Mask	Emanuel, Alexander & Churchill	WADC TR 58-505 March 1959, AD 213 604

ABSTRACT: A sizing program for oral-nasal oxygen masks, based on total face length and lip length, has been developed through a reanalysis of the 1950 USAF Anthropometric Survey head and face data. Face forms, based on this sizing program, have been constructed for use in the preparation of such masks. The MC-1 Oxygen Mask, an oral-nasal, pressure-demand type mask, has been fabricated in accordance with this sizing system and through the use of these face forms. In the fit-tests, one hundred forty-nine of one hundred fifty subjects fit-tested were satisfactorily fitted in their indicated sizes.

This report includes a discussion of the theoretical and practical aspects of the sizing procedure. Design limits and related statistical material and suggested procurement tariffs for each of the six sizes proposed are given. The MC-1 mask is described and the fit-test procedure and results are presented.

Title	Authors	Report Number and Date
A Supine Seat for High-Stress Testing of Primates	Eisen & Zeigen	WADC TR 59-165 April 1959, AD 219 894

ABSTRACT: This study summarizes the design rationale of a supine seat and restraint harness, with surrounding inclosure, for high stress bioscience experiments with a Macaca cynomolgus monkey (Macaca iris). This configuration is intended for test under various abnormal stresses, including high g centrifuge runs. Testing and feeding of the subject in the inclosure will be accomplished to determine his reaction to these stresses. With minimum modification, the Macaque supine seat and restraint harness could accept any primate for ground tests or bioexperiments in space flight. A brief description of an earlier supine test seat and restraint harness for low-stress experiments using a squirrel monkey is included.

Title	Authors	Report Number and Date
A Height-Weight Sizing System for Flight Clothing	Emanuel, Alexander, Churchill & Truett	WADC TR 56-365 April 1959, AD 130 917

ABSTRACT: This report presents a height-weight sizing system for use by designers and fitters of flight clothing. The observations and recommendations reported here are based on a reanalysis of the body size data of the 1950 Anthropometric Survey of Air Force flying personnel.

This reanalysis consisted of selecting pairs of dimensions and correlating these with other dimensions important in clothing design. Among the

pairs studied, height and weight have been chosen as basic sizing dimensions. In addition to presenting the methodology used in the present problem, the practical and statistical problems of developing a sizing system are thoroughly discussed. Finally, tables of body dimensional data are presented for several basic size programs (6-size, 8-size, 9-size, and 12-size), since the number of sizes varies with the type of garment. These tables include fitting charts, estimated procurement tariffs, design ranges, mean values for size groups, and bivariate tables for height and weight with size categories marked off for each program. The choice and application of these programs are discussed in detail.

Descriptions of the selected body dimensions are included.

Advantages of the height-weight system include improved fit, fewer alterations, minimal adjustability, and simplified procurement, distribution and fitting procedures.

Title	Authors	Report Number and Date
The Anthropometry of the Manual Work Space for the Seated Subject	Dempster, Gabel & Felts	Am. Jour. Phys. Anthrop. 17:4, 289-317, Dec 1959 (Also published as ASD TR 61-89, April 1961, AD 258 564.)

ABSTRACT: The anthropometry of the manual work area was approached by an indirect method using photo records of time exposures showing the motions of a tiny neon lamp as the hand grip. The records of 22 male subjects were analyzed for 3 sets of motions involving the forward-directed hand and different grip orientations. Techniques were developed for defining the limits of the space within reach relative to the mid-sagittal junction of the seat and chair back. Graphical records of the different hand-range spaces were grouped and compared to bring out variability data, the extent of right-left hand overlap, regions of maximum hand flexibility, mean hand positions, etc. The data have been discussed in relation to the geometry of the more effective hand positions and in relation to practical problems of work space designing.

Title	Authors	Report Number and Date
Dynamic Anthropometry of Working Positions	Hertzberg	Hum. Factors Bulletin, 2 147-155, August 1960 (Also published as ASD TR 61-90, July 1961, AD 263 715.)

ABSTRACT: This paper provides a review of the principles and procedures of workspace design for engineers. It emphasizes that human body size, anthropometry, and muscle force capability, biomechanics, are both essential for the efficient sizing of equipment. The proper method of workspace design, the "design limits concept," is described, and the fallacy of the "average man" concept is demonstrated. General methods of gathering body size and strength data are outlined, and major information sources noted. The author's ideas on human muscle strength in the weightless state are included.

Title	Authors	Report Number and Date
A Head Circumference Sizing System for Helmet Design: Including Three-Dimensional Presentation of Anthropometric Data	Zeigen, Alexander, & Churchill (Consultants: Emanuel & Velsey)	WADD TR 60-631 December 1960 AD 251 939

ABSTRACT: A system for the sizing and design of rigid and semi-rigid helmets based on a single key dimension, head circumference, is described. Anthropometric data largely obtained in the 1950 survey of Air Force flying personnel were analyzed. The three sizing programs discussed in terms of tabular data are also referred to in terms of headforms or three-dimensional representations of these data. These programs are a Six-Size Program based on mean values, a Three-Size Program based on mean values, and a Six-Size Program for helmet liner problems.

This report includes an account of the historical development of sizing systems, programs, and resultant headforms in the Air Force; a detailed statement concerning the design rationale and statistical concepts used; comprehensive tables needed by the designer for all sizing programs discussed; a statement as to sculpturing techniques and problems; and a comment on preliminary validation results and on the overall design-material-sizing concept.

Appendices include a glossary of significant terms, descriptions of selected head and face dimensions, a detailed discussion of statistical concepts and formulae referred to in the report and tables of comparative Four- and Six-Size Programs based on the key dimensions: head length, head breadth.

Title	Authors	Report Number and Date
Anthropometric Data Presented in Three-Dimensional Forms	Alexander, Zeigen & Emanuel	Am. Jour. Phys. Anthrop. 19:2, 147-157, June 1961 (Also published as ASD TR 61-599, October 1961.)

ABSTRACT: The Anthropology Section, Aeronautical Systems Division, has used new as well as standard approaches in the attempt to translate anthropometric data into three-dimensional forms. Basic anthropometric data must be interpreted for the designer and engineer prior to their application to practical problems. One recognized method of presentation is summating each dimension under its mean, standard deviation and percentiles. This approach has been proved quite acceptable for workspace situations concerned with gross measurements. On the other hand, considerable confusion exists among designers and engineers when it comes to handling anthropometric data for items of close-fitting protective equipment, e.g., pressure suits, oxygen masks and helmets. In the past, various head and body forms have been fabricated to provide the designers with more concrete expressions of anthropometric data. Recent efforts along these lines have led to the development of new three-dimensional forms, some of general application and others for specific problems. All of the current approaches employ key dimensions chosen to determine size ranges. Items included under this program are (1) a series of faceforms (key dimensions are total face length and lip length), (2) two series of headforms (both using head circumference as the key dimension), and (3) a series of body manikins (based on height and weight). The special set of faceforms has been used to size a new light-weight oxygen mask; the two headform series are in use for the experimental sizing of various helmets; and the body manikins are being fabricated to represent a range of body sizes using a height-weight system for flight clothing. The design rationale on which these forms are based and the difficulties encountered in sculpturing them to dimension are discussed.

Title	Authors	Report Number and Date
Nylon Net Seat for a Modified RB-57 Aircraft	Hertzberg	ASD TR 61-206 Dec 1961, AD 280 049

ABSTRACT: A light-weight, adjustable, easily demountable net seat for persons who must operate in cramped quarters is described. Tests lasting for more than a year in a modified RB-57 have shown the seat to be fully satisfactory. Design drawings and photographs of the method of installation are included.

Title	Authors	Report Number and Date
X-Ray Anthropometry of the Hand	Joan Haskell Vicinus	AMRL-TDR-62-111 September 1962, AD 291 412

ABSTRACT: Presented in this report is a comprehensive descriptive summary of the roentgenographic anthropometry of the hand. The 253 subjects chosen for measurement have been selected so as to be representative of the Air Force population in hand length and hand breadth.

Summary statistics for 24 lengths and 20 breadths for both the left and the right hands are presented. Also included in the report are complete intercorrelation matrices for both hands indicating the degree of interrelationship between the 44 dimensions.

Analysis of the data indicates that, in general, the right hand tends to be longer and broader than the left with the right hand showing slightly greater variability in length and less variability in breadth than the left. The lowest correlations occur in the relationships between length and breadth dimensions, and the highest are to be found within the length dimensions of each of the five digits.

Title	Authors	Report Number and Date
Moments of Inertia and Centers of Gravity of the Living Human Body	Santschi, DuBois, & Omoto	AMRL-TDR-63-36 May 1963, AD 410 451

ABSTRACT: A study was conducted to determine the moments of inertia and centers of gravity of a sample of 66 living male subjects representative of the Air Force population in stature and weight. Eight body positions were investigated: Standing; Standing, Arms Over Head; Spread Eagle; Sitting; Sitting, Forearms Down; Sitting, Thighs Elevated; Mercury Configuration; Relaxed (Weightless). The procedure was based upon the compound pendulum having a theoretical accuracy of approximately ± 2 to ± 8 per cent depending upon position and axis. Orthogonal axes, defined as the intersections of the sagittal, frontal, and transverse planes through the standing body, were designated as X, Y, and Z. A set of 50 anthropometric dimensions was taken on each subject, as well as photographs of each subject in each position. Results of the study show that the average moment of inertia varied in this sample from 11 pounds in $sec.^2$ about the Z axis to 152 pounds in $sec.^2$ about the X axis. Linear regression analysis of moments of inertia vs. stature and weight yielded correlation coefficients ranging between 0.77 and 0.98.

Title	Authors	Report Number and Date
Anthropometric Data in Three-Dimensional Form: USAF Height-Weight Sizing Manikins	McConville, Alexander & Velsey	AMRL-TDR-63-55 June 1963, AD 411 556

ABSTRACT: This report describes the development of data and the sculpturing of manikins for use in designing Air Force protective garments and associated personal equipment, as part of a long-range program to present designers of protective flight equipment with a variety of anthropometric data in three-dimensional form.

In part, the data are based on a reanalysis of the body statistics reported in WADC Technical Report 56-365, A Height-Weight Sizing System For Flight Clothing, with certain changes in the statistical rationale required by either functional or technical factors. The choice and application of the statistical data used are discussed in detail. Information is also given concerning the sculpturing techniques used in the fabrication of the body forms.

Supplementary anthropometric statistics describing the human body in a seated position are presented. These statistics are analyzed in accordance with the Eight-Size Height-Weight sizing system.

Title	Authors	Report Number and Date
Anthropometric Survey of Turkey, Greece and Italy	Hertzberg, Churchill, Dupertuis, White & Damon	AGARDograph No. 73 The Macmillan Co., New York, 1963, AD 421 428

ABSTRACT: This report describes the planning and organization of the NATO Anthropometric Survey of 1960-61, and presents the tabulated data for 150 body dimensions taken on 3356 military personnel: 915 Turks, 1084 Greeks, and 1357 Italians. Besides body dimensions, the data gathered include sociological and military information, somatotype photographs, skinfold thicknesses and other measures on each subject permitting assessment of body composition. (Taken during the Survey, but omitted from this volume, are data from X-ray photographs of the right hands of 150 Greek and 150 Italian subjects.) The tabulated data include the means, standard deviations, coefficients of variation of 150 body dimensions, as well as selected percentiles of each form from the 1st to the 99th, for each total national sample and subsample. When available, USAF data are presented for comparison. Each dimensional listing is accompanied by a sketch locating the dimension, a photograph illustrating the technique of measurement, and verbal instructions for procedure.

There are chapters, each signed by its own author, presenting team acknowledgements, an introduction to the problem, the technical procedures used, and a summary of the statistical methods employed. A preliminary somatotype study (based on every 10th man) describes the body types encountered, with illustrations of four physical types from each country; and an analysis of skinfold-thickness data presents an estimate of body fat in the sample. A final chapter sketches the history of anthropometric surveys, and outlines the wider practical and scientific uses of anthropometric data. Appendixes I and II present plans for the construction of special equipment, and Appendix III briefly outlines plans for future publications on these data.

The volume contains a Table of Contents, an Index of Dimensions, a Visual Index of body dimensions, a Glossary, a Bibliography, and many illustrations.

Title	Authors	Report Number and Date
Anthropometry of Japanese Pilot	Oshima, et.al., & Alexander	Rpts of Aeromedical Lab 2:2, March 1962 (Japanese) (Also published as AMRL-TR-65-74, March 1965, AD 462 062.)

ABSTRACT: This report presents the results of a body size survey conducted by Japanese flight surgeons in the Spring of 1961. Sixty-two measurements were taken on 239 Japanese pilots at five different bases throughout Japan. Data reported include the mean, standard deviation, coefficient of variation and percentiles of each measurement. Also included are statistical comparisons between the Japanese and USAF flying populations.

Title	Authors	Report Number and Date
Anthropometry	Damon, Stoudt & McFarland	Chap. 11, Morgan, et.al., Eds.; Human Engr Guide to Equipment Design, McGraw Hill Book Co., Inc.; New York, Toronto, London, 1963

ABSTRACT: This 130-page chapter contains extensive anthropometric, muscle-strength, and range-of-motion of body-segment data on numerous United States military populations. Their application to many types of human engineering problems is detailed.

Title	Authors	Report Number and Date
Helmet Visor Defog Capabilities & General Evaluation of the G-2C-1 Space Suit Assembly	Middleton, Muick, Alexander & Klemm	Tech Memo SEM-TM-63-3 November 1963

ABSTRACT: The purpose of these evaluations is (1) to determine the capability of the Gemini prototype ventilation system to keep the helmet visor from fogging during various abort and/or emergency phases of the

Gemini mission; (2) to determine what fogging solution will be adequate to prevent visor fogging in the event the ventilating system is inadequate during emergency orbital conditions; (3) to measure suit volume, body volume of the subject, and dead air space between suit and subject as a means of determining the efficiency of the ventilating system; and (4) to determine growth increments (ballooning) during the inflated state of the suit.

Title	Authors	Report Number and Date
HUMAN MECHANICS: FOUR MONOGRAPHS ABRIDGED	Krogman & Johnston	AMRL-TDR-63-123 December 1963 AD 600 618
(1. Center of Gravity of the Human Body	Braune & Fischer	
2. Theoretical Fundamentals for a Mechanics of Living Bodies	Fischer	
3. The Human Motor	Amar	
4. Space Requirements of the Seated Operator)	Dempster	

ABSTRACT: This report condenses four important monographs in the field of applied human mechanics.

The Center of Gravity in the Human Body is a study of the main center of gravity in the human body and the centers of its several parts. It is based upon the measurement and positional analysis of four frozen adult male cadavers, projected to an x, y, z coordinate system. The basic data are transferred to a living adult male soldier, with and without load, in differing military positions.

Theoretical Fundamentals for a Mechanics of Living Bodies is the analysis of freely movable joint systems ("n-link systems") in the living human body. The aim is (1) to present the kinetics of joint systems, and (2) the analysis of states of motion and equilibrium. Part I presents a three-link joint system and the n-link plane and solid joint system. Part II is an application to the mechanics of the human body and to motion in machines (latter here omitted).

The Human Motor is devoted to the application of principles of mechanics to bodily movements, specifically oriented to work-situations. There are discussions of musclebone kinetics in structure and function; the physiology of fatigue is stressed. Environmental factors are discussed:

external, as climate, temperature, altitude, etc.; internal, as heart, lungs, nutrition, etc. Experimental devices to measure energy exhange are given. All data are finally interpreted in terms of actual work performance in tool use, time, and motion, etc.

Space Requirements of the Seated Operator is the analysis of the human body, utilizing osteological material, cadavers, and living subjects, in terms of body links and kinetics, differential tissue relationships, physique differences, and the range of normal variation, carried out for the purpose of more precisely defining the work space required by seated individuals in various tasks. The results consist in the presentation of these requirements for a variety of seated functional postures, as well as detailed plans for the construction of kinetically-correct two- and three-dimensional manikins.

Title	Authors	Report Number and Date
Finger Dexterity of the Pressure-Suited Subject	Walk	AMRL-TDR-64-41 May 1964, AD 603 705

ABSTRACT: This study attempts to establish an objective baseline for evaluating the functional mobility of pressure gloves. The Purdue Pegboard Dexterity Test was employed to measure hand dexterity under three conditions: (1) subjects barehanded, but wearing an unpressurized A/P22S-2 full-pressure suit ensemble; (2) subjects gloved (HAK-3/P-22S-2) and suited, but not pressurized; (3) subjects gloved, suited, and pressurized to 2.5 psi. The Purdue Pegboard Dexterity Test has been found to be a delicate indicator of hand dexterity in the test conditions. The test results show a marked reduction in dexterity even with the gloves and suit uninflated, and an additional loss when gloves and suit are inflated. The degree of loss of dexterity is believed to provide an objective measure whereby one operational aspect of pressure gloves may be evaluated.

Title	Authors	Report Number and Date
Height-Weight Sizing of Protective Garments, Based on Japanese Air Self-Defense Force Pilot Data, with Fit-Test Results	Alexander, McConville, Kramer & Fritz	AMRL-TDR-64-66 July 1964, AD 606 039

ABSTRACT: This study discusses the development and test of a four-size Height-Weight sizing program of partial pressure and exposure suits designed for the Japanese Air Self-Defense Force. The sizing program is based upon an anthropometric survey of over 200 subjects, conducted at five air bases throughout Japan during the spring of 1961.

The statistical rationale used in devising the Height-Weight program is presented along with the analysis of the anthropometric data. Two garments, the CSU-7/P Partial Pressure Assembly and the CWU-13/P Exposure Garment, were fabricated in accordance with the developed sizing program. A fit-test of these garments was conducted at Hamamatsu and Tachikawa Air Bases, Japan, in April 1963.

The results of the fit-tests served to validate the soundness of the basic survey data and subsequent development of the Height-Weight sizing program.

Title	Authors	Report Number and Date
Reach Capability of the USAF Population	Kennedy	AMRL-TDR-64-59 September 1964, AD 608 269

ABSTRACT: This report contains descriptions of the outer boundaries of the Minimum, 5th-, 50th-, and 95th-percentile grasping-reach envelopes of seated, shirt-sleeved operators. The two most important are the Minimum and 5th-percentile envelopes. These envelopes have been calculated to permit 99+ percent or 95 percent of the Air Force population, respectively, to reach any point at their boundaries. The report contains a critical resume of previous investigations of arm reach, and a description of the AMRL Grasping-Reach Measuring Device. The data-gathering and statistical procedures are included, and applications of the reach envelopes are discussed. Horizontal contours representing the outer boundary of the Minimum, 5th-, 50th-, and 95th-percentile grasping-reach envelopes are presented for each 5-inch level beginning at 5 inches below SRP (Seat Reference Point) and extending to 50 inches above SRP. The Minimum envelopes extended from 2.5 inches below SRP to 48 inches above; the 5th-percentile envelope from 4 inches below SRP to 48.75 inches above. Horizontal distances from SRP to the boundary of each envelope are given at 15° intervals.

Title	Authors	Report Number and Date
Moments of Inertia and Centers of Gravity of the Living Human Body Encumbered by a Full-Pressure Suit	DuBois, Santschi, Walton, Scott & Mazy	AMRL-TR-64-110 November 1964 AD 609 863

ABSTRACT: The center of gravity and the moments of inertia of each of 19 male subjects, representative in stature and weight of the U.S. Air Force population, were determined. Two body positions: sitting and relaxed; and three modes of dress: nude, suited-unpressurized, and suited-pressurized, were investigated. The theoretical accuracy of the

experimental procedures, based on a compound pendulum, ranged from 2 to 8 percent, depending on body position and axis. The moments of inertia were found to vary significantly between body positions and between nude and suited conditions. Correlation coefficients between the moments of inertia and stature and weight exceeded 0.9. Fifty anthropometric dimensions and frontal and profile photographs were obtained on each subject to serve as the basis for additional biodynamic analyses.

Title	Authors	Report Number and Date
The Use of Lines of Nonextension to Improve Mobility in Full-Pressure Suits	Iberall	AMRL-TR-64-118 November 1964 AD 610 519

ABSTRACT: An important objective in the development of a full-pressure suit for a human being is to permit the wearer full mobility without interfering with physical capability. Although the human skin is stretched during body motion, there is virtually no stretch along certain lines, here called "lines of nonextension." This investigation was undertaken to determine the efficacy of utilizing lines of nonextension to provide natural mobility and minimal ballooning in full-pressure suits. The program of investigation pursued was: (1) to map out these lines of nonextension, (2) to test whether string elements of high elastic modulus, a connected network, could be laid along these lines of nonextension without providing any constraint to mobility, (3) to obtain a highly mobile pressure-retaining layer to be constrained by the net, and (4) to construct and demonstrate an entire pressure-retaining garment system that makes use of necessary layers and string elements in a completely connected, netted covering for the body, with minimal constraint to mobility up to 5 psi. The technique, result, and collateral observations relevant to each of these phases are described. A mobile, pressure-retaining garment was developed by building each structural, functional layer into the composite garment in accordance with the basic design theory.

Title	Authors	Report Number and Date
Motion Performance of Pressure-Suited Subjects Under Zero and Lunar Gravity Conditions	Simons, Walk & Sears	Aerospace Medicine 36:5, 406-414, May 1965

ABSTRACT: The motions of unsuited and pressure-suited subjects were studied as they performed lunging, egressing and landing tasks during the weightless and lunar gravity maneuvers of a large cabin aircraft. Performance data are presented for various combinations of clothing, gravity and body position conditions. Time and contact data are

presented for the egress motion as it is influenced by changes in the exit diameter. Motions of suited subjects generally required 30 per cent more time than corresponding motions of unsuited subjects under both gravity levels. Most motions required 35 per cent more time during zero-G than during lunar-G. No significant differences in egress time were found for four body-position configurations. Five inches of exit clearance improved egress time by 6 per cent. Accuracy of motion rather than time of motion appeared to be a more sensitive measure of operator performance for the egress task.

Title	Authors	Report Number and Date
The Anthropometry of Common Working Positions	Alexander & Clauser	AMRL-TR-65-73 December 1965, AD 632 241

ABSTRACT: Twenty-six dimensions of the human body in various working positions (standing, bending, kneeling, squatting, supine and sitting) were obtained by photography or by direct measurement. The purpose of this study was to provide the human engineer with anthropometric data of various missile worker's positions so that more adequate work stations can be designed. Each dimension is defined verbally and graphically; and the 5th, 25th, 50th, 75th and 95th percentiles and other statistical data are presented.

Title	Authors	Report Number and Date
Development of Design Standards for Ground Support Consoles	Kennedy & Bates	AMRL-TR-65-163 December 1965 AD 630 639

ABSTRACT: Experience gained in using a single standardized ground-support console configuration in the WS 131B, Hound Dog, is discussed. Other ground console designs for possible standardization in future systems are described in detail. All designs are derived from a basic sit-stand configuration and will accommodate approximately 95% of the USAF male population and approximately 60% of the USAF female population. Each of the consoles can be made from five standard subassemblies. The suggested standard configurations permit engineering design freedom, yet restrict certain dimensional characteristics of the consoles to assure accommodation to the requirements and capabilities of the operator.

Title	Authors	Report Number and Date
Aperture Sizes and Depths of Reach for One- and Two-Handed Tasks	Kennedy & Filler	AMRL-TR-66-27 February 1966 AD 646 716

ABSTRACT: This report presents data on (1) the optimal sizes and locations of maintenance apertures, and (2) man's working-reach distances through such apertures, for both the shirt-sleeved and the pressure-suited conditions. In all cases, the vertical dimension of the aperture permits the technicians to maintain simultaneous visual and manual contact with the task area. Data include Depth of Reach, Breadth of Aperture, Vertical Dimension of Aperture, and the distances from the floor from both the lower and the upper edges of these apertures. Different apertures provide for forward or lateral reaches, in the standing or seated position, with one or both arms.

Data are reported in percentiles, including the 5th, 25th, 50th, 75th, and 95th. Ranges, means and standard deviations are given. Recommendations are made regarding the appropriate application of the data to the sizing and location of maintenance accesses.

Title	Authors	Report Number and Date
A Study of One-Handed Lifting	McConville & Hertzberg	AMRL-TR-66-17, April 1966 AD 637 764

ABSTRACT: This research is intended to assist in establishing realistic criteria for the size and weight of industrial packages. The problem of such criteria is discussed, numerous important objective and subjective factors that potentially affect human weight-lifting ability are mentioned, the proper approach to the design of industrial loads is pointed out, and additional programs of investigation that would clarify other aspects of the problem are outlines. This study examined the interaction of two variables--(a) the weight and (b) the width--of one-handed symmetrical boxes which a sample of 30 adult males were able to lift from the floor to a table 30 inches high. No carrying was involved in this study. The subject sample was chosen to be a reasonable representation by height and weight of the U.S. Air Force population. All lifts were made with the preferred hand under "ideal" laboratory conditions. The experimental variable, box width, was varied from 6 to 32 inches. The maximum weight of box that subjects were able to lift varied linearly, but inversely, with the width of the box. From this sample, the maximum weight that 95% of the population would be able to lift--but not necessarily carry--can be expressed by a linear equation:

Weight (pounds) = 60 - width (inches).

The numerical values of this formula provide a recommended upper limit on the design of industrial or military equipment which must be lifted under ideal conditions. If the expected conditions of use are less than ideal, or if carrying for appreciable distances is likely to be necessary, reasonable reductions in weight, or size, or both should be made by the manufacturer.

Title	Authors	Report Number and Date
Relationships Between Flexibility, Anthropometry, and the Somatotype of College Men	Laubach & McConville	Research Quarterly, 37:2, 241-251, May 1966 (Also published as AMRL-TR-65-31, May 1966.) AD 638 282

ABSTRACT: Fourteen flexibility measurements, 63 direct and derived anthropometric measurements, and the somatotype of 63 college men, mean age of 19.0 years, were obtained in order to assess the relationships between flexibility and anthropometric measurements, anthropometric measurements and somatotype, and flexibility and somatotypes. The correlations between the flexibility measurements and the anthropometric measurements were low and mostly insignificant. Body fat, as measured by skinfold calipers, yielded fairly high significant negative correlations with the flexibility measurements. The correlations between the flexibility measurements and somatotype were insignificant. Generally high correlation coefficients were obtained between the anthropometric measurements and somatotypes.

Title	Authors	Report Number and Date
Muscle Strength, Flexibility, and Body Size of Adult Males	Laubach & McConville	Research Quarterly, 37:3, 384-392, October 1966 (Also published as AMRL-TR-65-107.)

ABSTRACT: Four measures of muscle strength, two measures of flexibility, 30 anthropometric measures (both direct and indirect), and the somatotypes of 45 male subjects were obtained and the interrelationships among these variables investigated.

A low but statistically significant correlation was found between hip-flexion strength and the range of motion of hip extension-flexion; however, this was the only strength measurement to correlate significantly with the flexibility measurements. Many statistically significant ($p = .05$) correlations were found between the anthropometric and the strength measurements, but none between the anthropometric and the flexibility measurements. The only somatotype component to correlate significantly with the measures

of muscle strength was mesomorphy; the correlations between the somatotype components and the measures of flexibility were insignificant.

Title	Authors	Report Number and Date
An "Anvil" for Sliding-Caliper Repair	Hertzberg	Am.Jour.Phys.Anthrop., 25:3, 335-336, November 1966

ABSTRACT: This note presents working drawings and a photograph of a tool that facilitates immediate repair of sliding calipers damaged during anthropometric surveys.

Title	Authors	Report Number and Date
Measurement of Muscle Strength	Laubach & Alexander	Sec VIII, Metzger and Fritz, Eds.; Integrated Life Support System Study, AMRL-TR-66-185, December 1966, AD 656 311

ABSTRACT: Tests are conducted to define the various problems involved in the maintenance of an acceptable environment, the number of variables concerned with the man-machine concept, the operation, maintenance and evaluation of single units and integrated systems for the support of life in a simulated aerospace mission. The investigation covers primary problems and benefits associated with water recovery, personal hygiene, sanitation, nutrition, instrumentation, atmospheric conditions at various pressures and mixtures, clothing, crew accommodations, waste management and muscle-strength while confined in a chamber simulating an aerospace vehicle, and the facilities and support required to test and evaluate life support systems.

Title	Authors	Report Number and Date
Maximal Static Force vs. Stress Measurements as Criteria for Establishing Optimal Work Conditions	Kroemer	Proceedings of 38th Annual Scientific Mtg of Aerospace Medical Association, 166-167, 1967 (Also published as AMRL-TR-67-32.)

ABSTRACT: Differences between static and dynamic usage of muscles and ensuing consequences for arrangements of controls are discussed. Methods of assessment of physical stress of human operators are briefly reviewed.

In a series of experiments, eight male subjects operated cranks and levers (radii 15 and 30 cm) against torques of resistance of 2 to 6.8 m.kp.

During trials of 10 minutes each, the subject performed either 100 or 200 to-and-fro movements, the angles of rotation being 90 or 180 degrees. The range of travel of the handles was adjusted to a variety of positions within the reach capabilities of the subjects. Experimental conditions judged by the subjects as most agreeable and which, at the same time caused least increases in their pulse rates, were considered to be optimal for the dynamic work performed.

The results obtained indicate that measurements of man's maximal static forces do not provide an adequate basis for the layout of controls which must enable human operators to perform dynamic-submaximal work with the least amount of fatigue and physical stress.

Title	Authors	Report Number and Date
Two-Handed Retention on Various Handle Configurations	Garrett, Alexander & Bennett	AMRL-TR-67-63, May 1967 AD 658 441

ABSTRACT: This report presents data on the manual grip-retention capability of seated persons. Nine male subjects, grasping experimental ejection actuators located forward of an ejection seat pan, were required to maintain their grasp against force loadings of 50 to 500 pounds. Grip retention at various increments of time to a maximum of 30 seconds are compared for each of the four handles: a T-bar, Twin grips, a standard D-ring and a flexibile Gemini-type loop. Test results indicated that the T-bar provides the greatest grip-retention capability. Potential applications of these performance data are discussed.

Title	Authors	Report Number and Date
Notes on Anthropometric Technique: Anthropometric Measurements--Right and Left Sides	Laubach & McConville	Am.Jour.Phys.Anthrop. 26:3, 367-370, May 1967 (Also published as AMRL-TR-67-82.)

ABSTRACT: In order to discover whether statistically significant differences exist between measurements taken on the right and left sides of the body, 21 such anthropometric dimensions were compared. In eight cases significant differences were found. Six of these dealt with the forelimb, in which the dimension measured on the right side was greater. Since data on handedness is lacking we do not know whether this is related to the handedness of the subjects.

Title	Authors	Report Number and Date
The Conference on Standardization of Anthropometric Techniques and Terminology	Hertzberg	Am.Jour.Phys.Anthrop., 28:1, January 1968 (Also published as AMRL-TR-67-180.) AD 708 118

ABSTRACT: The conference, attended by anthropologists, engineers, dental and medical researchers, physical educationists and statisticians, took place on 28-30 March 1967 in the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. The ultimate purpose was to improve the comparability of anthropometric data from all workers, by establishing standards for the many new dimensions required in engineering anthropology, and by developing a terminology that reconciles the new standards with previous usages. In this effort, the group selected a list of dimensions (though with dissent on type and number) recommended as a minimum for all human biological surveys; and they chose from previous usage a terminological structure whose form, content and mode of presentation they recommended as standard practice by all anthropometrists. Both official and dissenting lists are presented, and the terminological structure is described, with examples.

Despite solid progress toward a standardized technology encompassing both classical and modern practices, the conference left numerous points of technique or terminology unsettled, some of which are briefly described. Hence future meetings appear necessary, perhaps annually, until such remaining problems can be resolved.

Title	Authors	Report Number and Date
Anthropometric Dimensions of the Human Ear (A Photogrammetric Study of USAF Flight Personnel)	Alexander & Laubach	AMRL-TR-67-203 January 1968 AD 670 869

ABSTRACT: A technique was developed which enables precisely specified ear dimensions to be measured directly from PhotoMetriC slides. Summary statistics for each of the various ear dimensions are presented for a sample of 500 subjects randomly chosen from a total series of 2236 photographic slides collected during the 1957 Anthropometric Survey of USAF male flying personnel. Regression equations for predicting the various Tragus Radii angular measurements from the measurements of Ear Length and Ear Breadth are presented. The reliability and objectivity of the technique is discussed. A complete intercorrelation matrix for all variables studied in this research is also shown.

Title	Authors	Report Number and Date
Ergonomics in the Design of Office Furniture (A Review of European Literature)	Kroemer & Robinette	AMRL-TR-68-80, July 1968, AD 848 621 (Also published in Industrial Medicine & Surgery, 38:4, 115-125, April 1969, with partial list of references.)

ABSTRACT: This report discusses the European literature on "healthy" sitting postures and, relatedly, of suitable office and shop furniture, especially of chairs. Recommendations by orthopedists, physiologists, and physical anthropologists are summarized and tabulated for the height, shape, and dimensions of the seat surface; for the shape and dimensions of the back rest; and for the height of office desks, as well as for tables and stands to be used with office machines, such as typewriters.

Title	Authors	Report Number and Date
Clearance and Performance Values for the Barehanded and Pressure Gloved Operator	Garrett	AMRL-TR-68-24 August 1968 AD 681 457

ABSTRACT: This study provides the design engineer with clearance and performance values for operators wearing the A/P22S-2 pressure glove. Thirty-six anthropometric and biomechanical measures on the nude hand, gloved and unpressurized, and gloved and pressurized, were taken. The data for each measure on 27 subjects are both summarized for all subjects and reported independently by glove size worn. Possible uses for each of the measures are suggested and specific design factors for these uses are recommended.

Title	Authors	Report Number and Date
Ultrasonic Determination of Body Composition	Stouffer	AMRL-TR-68-61, December 1968, AD 695 470

ABSTRACT: The objective of this study was to determine the feasibility of using ultrasonic techniques to determine the volume of fat, muscle, and bone tissue of the living body. Ultrasonic equipment, including a mechanical scanning and recording device was used to produce cross-sectional maps of a live anesthetized hog, three fresh hams, and three human subjects (endomorphic, mesomorphic and ectomorphic). Thirteen 360 degree cross-sectional scans on the live hog demonstrated the feasibility of using the technique on live animals. Cross sections of the three hams demonstrated the accuracy of estimating the areas and volumes

of the three tissue components from ultrasonic scans. The ultrasonic mapping of the human subjects demonstrated that the technique could be used on all parts of the human body and, in addition, provided an indication of the range of values of individuals of diverse body types.

Title	Authors	Report Number and Date
World Diversity in Human Body Size and Its Meaning in American Aid Programs	Hertzberg	OAR Research Review, 7:12, December 1968 (Also published as AMRL-TR-68-113.)

ABSTRACT: This brief review shows quite conclusively that our Air Force people (and hence, our population at large) are giants as compared to these other populations. Not only is the large majority of the flying personnel among our Mediterranean and Oriental allies below our 50th percentile in most dimensions, showing that their sizes are different from ours, but also their proportions are different. Hence, smaller sizes of garments which fit us will not necessarily fit all of them adequately. In any case, it is inescapable that reliable anthropometric data on such populations are essential to the effective solution of the vexing and expensive fitting problems associated with clothing and equipment furnished our allies under our aid programs.

Title	Authors	Report Number and Date
Body Composition in Relation to Muscle Strength and Range of Joint Motion	Laubach	J. of Sports Medicine and Physical Fitness, 9:2, 89-97, June 1969 (Also published as AMRL-TR-67-135.) AD 716 632

ABSTRACT: The data on 27 body composition, anthropometric and physical performance items were obtained from 45 male subjects and the interrelationships among these measures investigated.

Many statistically significant ($p = .05$) zero-order correlations were found between the muscle strength and the body composition measures, but none between the range of joint motion measures and body composition. The somatotype components correlated much higher with measures of muscle strength when stature was partialled out of the correlation. The resulting correlations among the physical performance items and the body composition measures when body weight was held constant, were generally lower than the same zero-order correlations and first-order partial correlations (stature held constant).

A few (six) significant correlations were found between the range of joint motion and body composition measurements when both stature and body weight

were held constant. Multiple regression equations for the prediction of the physical performance items from the anthropometry and body composition measures are listed.

Title	Authors	Report Number and Date
Push Forces Exerted in Sixty-Five Common Working Positions	Kroemer	AMRL-TR-68-143, August 1969, AD 695 040

ABSTRACT: Experiments were conducted to measure the maximum isometric horizontal push forces exertable in 65 common working positions. The subjects (45 male college students), while pushing horizontally, either anchored their feet against a footrest or braced themselves against a vertical wall. Means, standard deviations, and 5th percentiles of the forces exerted are reported.

Male operators can exert horizontal static forces of at least 25 kp (55 lb) pushing with one hand, at least 50 kp (110 lb) pushing either with both hands or with the shoulder, and at least 75 kp (165 lb) pushing with the back--provided they anchor their feet or, better, brace themselves against a vertical wall. A vertical push-panel that allows most subjects to exert maximum horizontal force has a rough surface, is 40 cm (16 in) wide, and extends from 50 cm (20 in) above the floor to 125 cm (50 in) above the floor.

Title	Authors	Report Number and Date
Anthropometric Dimensions of Air Force Pressure-Suited Personnel for Work-space and Design Criteria	Alexander, Garrett, & Flannery	AMRL-TR-69-6, August 1969, AD 697 022

ABSTRACT: The results of an anthropometric survey of USAF personnel wearing the A/P22S-2 Full Pressure Suit fitted in accordance with the USAF Eight-Size, Height-Weight Sizing Program are presented. One hundred and thirty-eight measures were taken on each of thirty-four subjects standing, sitting and supine, with the suit in the uninflated, inflated, and inflated-restrained conditions. Forty circumferences were measured on a separate sample of thirty-two subjects standing and sitting, with the suit uninflated and inflated. Pictorial and verbal descriptions of the dimensions and detailed numerical results, including clearance ranges, are presented. Graphs comparing various dimensions across suit sizes are presented in the Appendix.

Title	Authors	Report Number and Date
Weight, Volume, and Center of Mass of Segments of the Human Body	Clauser, McConville	AMRL-TR-69-70, August 1969 AD 710 622 N70-29085

ABSTRACT: This study was designed to supplement existing knowledge of the weight, volume, and center of mass of segments of the human body and to permit their more accurate estimation on the living from anthropometric measurements. Weight, volume, and center of mass of 14 segments of the body were determined on 13 male cadavers. Presented are descriptive statistics of these variables as well as a series of regression equations predicting these parameters from anthropometry. Included in the seven supporting appendices are reports of studies of the mid-volume of segments as an approximation of their center of mass, relationships between standing and supine anthropometry and postmortem changes in gross body size, and comparisons between densities of fresh and preserved human tissues.

Title	Authors	Report Number and Date
Foot Operation of Controls: Speed and Accuracy of Foot Motions Between Targets	Kroemer	Preprints of IEEE-GMMS ERS International Symposium on Man-Machine Systems, Cambridge, Eng, September 1969

ABSTRACT: Circular targets, 15 cm between centers, were arranged in rows or columns of three at the reach envelope of the right foot. The subject, sitting on a short chair, moved his right foot as rapidly as possible from one target to an adjacent one. The thigh was kept horizontal while sagittal motions were performed in steps of 15 degrees between knee angles of 90 degrees (vertical) and 150 degrees (forward), or while lateral motions were performed 15 degrees to the left or right at each knee angle.

From the travel times, obtained from 20 male subjects, and from the segments of the goal targets hit first, the following conclusions were drawn:

> Forward motions of the vertical or almost vertical lower leg were slightly faster than either backward or lateral motions of the elevated lower leg. Such discrete motions can be learned very quickly and can be performed in about 0.1 seconds. The posture of the lower leg and the direction of motion had no appreciable effect on the accuracy of motion.

Title	Authors	Report Number and Date
"Zoom Bag Scenario"	Garrett & Alexander	Interceptor, 11:10-11, October/November 1969 (Also published as AMRL-TR-69-127.) AD 697 455

ABSTRACT: This article presents the background information concerning the joint efforts of the Anthropology Branch and Pressure Suit Depot, Tyndall AFB, Florida, in conducting anthropological research involving pressure-suited flight personnel.

Title	Authors	Report Number and Date
The Anthropology of Anthropomorphic Dummies	Hertzberg	Proceedings of the 13th Stapp Car Crash Conference, SAE #690805, 201-214, December 1969 (Also published as AMRL-TR-69-61.) AD 706 411

ABSTRACT: This paper describes anthropological aspects of a cooperative program to create a "family" of anthropomorphic dummies representative of the American population. The dummies are for use in crash-tests to improve public safety in motor vehicles. The anthropomorphic dummy is that type which closely approximates a given percentile level of the human body in size, form, segment mobility, total weight, segment weight, weight distribution and resiliency of its "flesh" covering, and is usually able to withstand 100 G. The history of this development is briefly sketched from its beginning in 1949. In the current program, the best available data have been chosen for three adult sizes: the 95th- and 50th-percentile males, and the 5th-percentile female. The body-forms being sculptured will provide a set of national standards for size, shape and weight. Future phases will involve the development of dummy organ-masses approximating the sizes and vibratory responses of those in the living torso. Deficiencies of the anatomical, anthropometric, biomechanical and physiological data used for these bodyforms are noted, and suggestions are made for improvement, so that future dummies may be made more reliably representative of the using population.

Title	Authors	Report Number and Date
The Relationship of Strength to Body Size and Typology	Laubach & McConville	Medicine & Science in Sports, 1:4, 189-194, December 1969 (Also published as AMRL-TR-69-107.) AD 705 450

ABSTRACT: Thirteen measures of static strength, 13 body-size measurements, and the somatotypes of 77 male subjects were obtained and the interrelationships among these measures were investigated. Summary descriptive statistics are given for the 29 variables studied. Simple and selected partial correlations were calculated and the results interpreted at the 0.05 level of significance.

The zero-order correlations revealed that body weight, lean body mass and mesomorphy yielded the highest correlations with mean total strength. Stature, skinfold measurements and the length of the lever arms of the body were not related to mean total strength; however, the relationship between the strength and length of specific torso and arm linkages while weak is definitely indicated. The first-order partial correlations (weight held constant) between body size measures, lean-body mass and strength measures were about the same as the identical zero-order correlations; however, with weight held constant the skinfold measurements yielded many significant correlations with muscle strength. By holding the effects of stature constant the somatotype components produced several significant correlations with the static-strength measures. The second-order partial correlations (weight and stature held constant) revealed that the subscapular and suprailiac skinfolds are more of a factor in the exertion of static strength than the triceps skinfold.

It would appear that the measures of body size, typology and composition used in this analysis were not effective predictors of muscle strength as measured by the static-contraction method.

Title	Authors	Report Number and Date
Human Strength: Terminology, Measurement and Interpretation of Data	Kroemer	Human Factors, 12:3, 297-313, 1970 (Also published as AMRL-TR-69-9.) AD 710 593

ABSTRACT: Application of strength data to human engineering problems is often hampered by ambiguities of both terminology and data. This paper attempts to point out some of the problems. After defining "strength" and clarifying related terms, mechanical, physiological, and statistical implications of strength testing are discussed. It becomes obvious that strength data are fully relevant to human engineering problems only if the operator must exert maximal static muscle force; if submaximal forces are required, the applicability of strength data is very limited. Research is needed to establish relations between human static force capacity and the abilities to perform maximal or submaximal dynamic work. At present there is little evidence that static force data accurately predict dynamic performance.

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Title	Authors	Report Number and Date
Industrial Seating	Kroemer	SME Report AD 70-138. Dearborn, MI: Society of Manufacturing Engineers, 1970 (Also published as AMRL-TR-70-11)

ABSTRACT: Sitting as a working position is less fatiguing than standing, and can, therefore, be maintained longer. It is also a more stable posture and allows better controlled motions. The sitting posture should be upright, but relaxed, without excessive curvatures of the spinal column, and with the thighs about horizontal. The seated person must be free to choose and change his posture; no specific postures should be forced upon him. There are many interactions among work station design, body posture of the worker, and task performance. Based on anthropometric and biomechanical data, design aspects of work seats as well as of foot rests, office equipment, consoles, work benches, machine stands, and the like are discussed. Recommended dimensions for such work stations are presented.

Title	Authors	Report Number and Date
Towards Standardization of Muscle Strength Testing	Kroemer & Howard	Medicine & Science in Sports, 2:4, 224-230, 1970 (Also published as AMRL-TR-70-124) AD 724 506

ABSTRACT: Male subjects (N=24) exerted maximal horizontal forces either trying to maintain a constant level over 5 seconds, or increasing steadily to the subjective maximum, or in vigorous jerks of the body. Statistical analysis ($p \leq 0.01$) indicated that these different techniques of force generation can result in different peak impulses. For the force maintained over 5 seconds, different scores (peak, and 12 averages during the exertion period) were extracted from the recorded force curves. Many of the resulting scores were significantly different from the others. Thus, a number of distinctly different "strength" scores resulted either from different techniques of force generation used by the subjects, or from different statistical treatments of the same raw data by the experimenter.

To standardize measures of "strength", a definition of strength, a checklist to control experimental techniques, and a regimen to calculate the strength index are proposed.

Title	Authors	Report Number and Date
Foot Operation of Controls: Speed of Activation & Exertion of Force to Pedals; Perception, Speed & Accuracy of Leg & Foot Motions	Kroemer	Ergonomics, 14:3, 333-361, 1971 (Also published as AMRL-TR-69-57) AD 707 142

ABSTRACT: The literature pertaining to foot operation of controls is reviewed and a new experiment reported.

Published experimental results clarify only some isolated aspects of leg and foot motions. Even the relatively often investigated speed of operating pedals and forces that can be applied to them were studied under such different experimental conditions that no general statements are possible concerning what pedal can be operated most quickly or forcibly. Opinions about the advantages and disadvantages of hand versus foot operation seem not generally based on experimental findings.

In an experiment, 20 seated young adult male subjects moved their right foot as rapidly as possible over distances of 15 cm to circular targets. The direction of these discrete movements had no appreciable effect on the accuracy of motion. Forward motions of the vertical or almost vertical lower leg were slightly faster than backward or lateral motions of the elevated lower leg. All motions could be performed in about 0.1 seconds.

Title	Authors	Report Number and Date
Anthropological Applications in High Altitude Flight Systems	Alexander, Garrett & Robinette	AMRL-TR-70-3, March 1970 AD 706 888

ABSTRACT: Anthropologists can provide data describing the human body as comprehensively as necessary, whether naked flesh or encumbered with protective equipment from head to toe. This article reflects only some of the research programs pursued in the Anthropology Branch on various phases of the dimensional requirements of the pressure suited man in the man-machine system. The spatial requirements for the man in a cockpit or capsule and on ejection and escape mechanisms or wearing clothing as protection against hostile environmental factors, such as heat, cold, vacuum, high g, and radiation, present separate problems for the design engineer that can be helped effectively with the applicable anthropological data.

Title	Authors	Report Number and Date
Anthropometry of the Air Force Females' Hand	Garrett	AMRL-TR-69-26, March 1970 AD 710 202

ABSTRACT: This report contains descriptions of 56 anthropometric dimensions measured on the hands of 211 Air Force female personnel (WAF, Nurse Corps and Biomedical Sciences Corps), aged 18-56. Summary statistics including the means, standard deviations, ranges, selected percentiles, measures of distribution and coefficients of variation are presented for the 56 dimensions. Also included are statistical variations by age, rank and Corps within the sample, a complete correlation matrix, bivariate tables, and nomographs for various selected combinations of dimensions.

Title	Authors	Report Number and Date
Anthropometry of the Hands of Male Air Force Flight Personnel	Garrett	AMRL-TR-69-42, March 1970 AD 709 883

ABSTRACT: This report contains descriptions of and data on 56 anthropometric dimensions of the hands of 148 male Air Force flight personnel. Selected dimensional comparisons indicate that this sample is representative of the total group of Air Force flight personnel. Summary statistics presented include the means, standard deviations, ranges, selected percentiles, and coefficients of variation. Also included are data on the age, rank, major Air Command, and commissioned status of the sample; a complete matrix of intercorrelations among the anthropometric dimensions; bivariate tables; multiple regression equations; and nomographs for selected combinations of dimensions. A tariff for the US Air Force 12-size glove program revised to reflect the latest anthropometric data is presented in the appendix.

Title	Authors	Report Number and Date
Problems in Assessing Muscle Strength	Kroemer & Howard	AMRL-TR-68-144, May 1970 AD 708 741

ABSTRACT: Muscle strength is typically reported in terms of "maximum." Experimental data illustrate the importance of defining the method of force exertion and of performance evaluation. Contracting the muscles in different ways or selecting different indexes from the same performance record can result in distinct "maximum" strength scores. To facilitate standardization of experimental procedures and comparison of strength data, a check list is proposed.

Title	Authors	Report Number and Date
Misconceptions Regarding the Design and Use of Anthropomorphic Dummies	Hertzberg	Motor Industry Research Association (MIRA) Bulletin #4, 17-21, July/August 1970 Lindley, Warwickshire, Eng. (Also published as AMRL-TR-70-25.)

ABSTRACT: This paper is a critique of a British article, "Anthropometric Dummies for Crash Research," by Searle and Haslegrave (Bulletin 5, Motor Industry Research Association, 1969), who sharply criticize an American commercial crash-test dummy. That paper, written by engineers, contains a variety of misconceptions regarding human biology and its influence on the design of crash-test dummies as well as on the choice of data for their construction. Because these views were widely disseminated in England, it

was considered necessary to rebut them by tested principles and data for the benefit of human factors science.

Title	Authors	Report Number and Date
"Average" Man is a Fiction: Range of Sizes is Key to Efficient Work Places	Hertzberg	Published as part of symposium, "Ergonomics: Man's Newest Environmental Science," in CONTRACT, 86-89, Sept 1970 (Also published as AMRL-TR-70-58.)

ABSTRACT: This paper briefly defines the multidisciplinary field variously termed "Ergonomics" (in Europe), and "Human Factors", "Human Engineering" or "Human Factors Engineering" (in the United States), and outlines the part played therein by the sub-field of Engineering Anthropology. This sub-field's basic subdivisions of anthropometry, workplace design, biomechanics, and studies of human discomfort (due to tissue compression) are briefly described, and some principles of use of such data are illustrated by examples from US Air Force experience. Some significant studies on work seats concerning the determination of discomfort and its amelioration are outlined, and the importance of data regarding body size and seating discomfort for furniture design is emphasized, especially for work seats and desks. In this connection, recent increases in body size in the American population are noted, and the sources of such data are named. A selected list of 35 references is appended.

Title	Authors	Report Number and Date
Placement of Aircraft Controls	Garrett, Alexander & Matthews	AMRL-TR-70-33, September 1970 AD 715 975, LC No. 70-607830

ABSTRACT: Data are presented to guide the designer in placing aircraft controls to be operated by lightly clothed or pressure-suited aircrewmen. The capabilities of 17 subjects wearing various combinations of personal equipment to reach 81 locations with a 180° arc forward of Seat Reference Point were determined. Each subject was tested while wearing personal equipment, consisting of an underarm life preserver, parachute harness and, successively, a K2B flight coverall, an uninflated, and an inflated A/P22S-2 Full-Pressure Suit. The subjects sat in a seat configured to approximate Air Force specifications. During the tests they were restrained in the seat by a lap belt and shoulder straps with the inertial reel locked and again with the inertial reel unlocked. Pictorial descriptions of the dimensions, the reach capabilities of each subject, and recommended design values are presented.

Title	Authors	Report Number and Date
Hand-Held Device to Measure Finger (Thumb) Strength	Kroemer & Gienapp	J. Applied Physiology, 29:4, 526-527, October 1970 (Also published as AMRL-TR-70-34) AD 717 793

ABSTRACT: A device that measures the force exerted by the thumb, or fingers, is described. This device is hand-held, easily calibrated, and is adjustable to various hand sizes and digit positions. Thumb strength data from 31 male subjects are reported.

Title	Authors	Report Number and Date
Horizontal Static Forces Exerted by Men Standing in Common Working Positions on Surfaces of Various Tractions	Kroemer & Robinson	AMRL-TR-70-114, January 1971, AD 720 252

ABSTRACT: Experiments were conducted to measure maximal isometric horizontal push forces. Twenty-eight male subjects pushed forward with both hands, laterally with the preferred shoulder, and with their backs. Reaction force for body stabilization was provided by a vertical wall, a footrest, or by floor-shoe combinations with coefficients of static friction of approximately 1.0, 0.6, and 0.3. Means, standard deviations, and 5th percentiles of the exerted forces are reported. In comparing the experimental data with results previously published, it is concluded that body weight cannot serve as a reliable predictor for push force capability from floors of various tractions. Estimates for static horizontal push as well as pull force capabilities of one or several men are tabulated in relation to traction available to the operator. An appendix contains coefficients of static friction between nineteen floor materials and eight shoe materials.

Title	Authors	Report Number and Date
The Adult Human Hand: Some Anthropometric and Biomechanical Considerations	Garrett	Human Factors, 13:2, April 1971 (Also published as AMRL-TR-69-122) AD 724 061

ABSTRACT: Recent studies of the anthropometry and selected biomechanical characteristics of hands are summarized. These include: 1) conventional anthropometry of male and female hands, 2) the anthropometry of the relaxed hand, 3) comparison of certain engineering anthropometric and performance parameters between bare and pressure-gloved hands, and 4) the ability to retain grips on selected handles under high dynamic loads. The utility of these data for human factors engineering is discussed.

Title	Authors	Report Number and Date
A Collation of Anthropometry	Garrett & Kennedy	AMRL-TR-68-1, June 1971 LC No. 74-607818 AD 723 629 (Vol 1) AD 723 630 (Vol 2)

ABSTRACT: Scientists and engineers are faced with the responsibility of comparing anthropometric data from different populations. So far, the labors required to find and identify comparable dimensions have been left to the individual researcher. To relieve him of the burden of this effort, the descriptions of approximately 2000 anthropometric dimensions from 47 sources have been collated and reported in a manner that makes comparisons convenient. Thirty-nine of these sources are primary sources of statistical

data. Thirty-six of the latter were published since 1940, and three are soon to be published. Several classic sources of anthropometric technique have also been collated.

Title	Authors	Report Number and Date
A Computer Program for Calculating Parnell's Anthropometric Phenotypes	Laubach & Marshall	Journal of Sports Medicine & Physical Fitness, 10:4, 217-224, December 1970 (Also published as AMRL-TR-68-151) AD 725 386

ABSTRACT: A specific computer program was written and compiled for the calculation of Parnell's anthropometric phenotype. This computer program is illustrated and discussed. A total of 2420 male subjects from the 1967 US Air Force Anthropometry Survey were phenotyped in this manner. Descriptive statistics for the phenotype distributions are given for the entire sample divided into 5-year age categories.

Title	Authors	Report Number and Date
Human Engineering the Keyboard	Kroemer	Human Factors, 14:1, 51-63, February 1972 (Also published as AMRL-TR-69-141)

ABSTRACT: The standard typewriter keyboard serves as a model for keyboards of teletype writers, desk calculators, consoles, computer keysets, cash registers, etc. This man-machine interface should be designed to allow high-frequency, error-free operation with the least possible strain on the operator. This paper discusses several feasible, biomechanical improvements of the keyboard. Some experimental findings are described which support the use of the following design concepts: a) the keys should be arranged in a "hand-configured" grouping to simplify the motion patterns of the fingers; b) the keyboard sections allotted to each hand should be physically separated to facilitate the positioning of the fingers, and c) the keyboard sections allotted to each hand should be declined laterally to reduce postural muscular strain of the operator.

Title	Authors	Report Number and Date
Anthropometry of Air Force Women	Clauser, Tucker, McConville, Churchill, Laubach & Reardon	AMRL-TR-70-5, April 1972 LC No. 72-600027

ABSTRACT: This report describes and summarizes the results of an anthropometric survey of US Air Force women carried out during 1968. Included in the report are a description of the methods and techniques used in the survey, descriptions--visual as well as verbal--of the measuring techniques used, and both uni- and bi-variate statistical summaries.

A total of 137 anthropometric dimensions were measured on a sample of 1,905 US Air Force women: 548 officers or officer trainees and 1,357 enlisted women. This anthropometry included 5 measures of weight and fat thickness, 30 measures of body height and length, 26 measures of body girths, 15 measures of body breadths and depths, and 12 measures of body surface distance. There were, in addition, 30 measures of the head and face, 3 of the hand, and 2 of the feet. Thirteen measurements were re-measures of the subject while she was wearing a foundation garment. Background data gathered included age, rank, military occupation, birthplace, blood type, and age at menarche.

Part A describes the survey and the sample, illustrates the measuring techniques, and provides summary statistics including the mean, standard deviation, coefficient of variation, selected percentiles, measures of skewness and kurtosis, and frequency distribution for each measured variable. A study of the body density of a subsample of 95 women is also included.

Part B provides a variety of correlation and regression equation material, including the complete correlation matrix for age, the basic 124 measurements, grip strength, regression equations for all pairs of variables with at least moderately high intercorrelations, selected partial and multiple correlations and a series of step-wise regression equations.

Part C consists of a set of approximately 400 bivariate frequency tables, plus one trivariate table.

Part D contains abbreviated statistical summaries for a set of indices, a group of computer variables, and for the original measurement data separately for the officers and the enlisted women.

Title	Authors	Report Number and Date
Engineering Anthropology	Hertzberg	Chapter 8, Human Engineering Guide to Equipment Design, 2nd Edition, US Government Printing Office, Wash., D.C. (in press)

ABSTRACT: This chapter is a revision and updating of Chapter 11 of the first edition. Its basic premise is that human factors design should no longer be a local American effort for the American population, but a world effort for world populations; and, therefore, the chapter presents selected data for populations on all continents, despite the relative paucity of data on many populations. The chapter contains digests of the most recent data on anthropometry, workspace, and muscle strength in machine design. An extensive bibliography is appended.

Title	Authors	Report Number and Date
Foot Forces Exerted at Various Aircraft Brake-Pedal Angles	Hertzberg & Burke	Human Factors 13(5), 445-456, October 1971 (Also published as AMRL-TR-70-75)

ABSTRACT: This study reports the forces (means and standard deviations) exerted by the foot at various angles of extension about its ankle. A sample of 100 rated pilots was used.

The forces were measured in a cockpit mock-up constructed around a specially instrumented F-80 rudder-pedal assembly. The right rudder pedal (hinged on the rudder bar) could be rigidly set to any desired angle between vertical and 75° forward of vertical. Foot forces were measured at 11 positions of the instrumented brake pedal, for both neutral and extended positions of the right leg, and in three cockpit sizes (37-inch, 39 1/4-inch, and 41-inch) --66 measures on each man. In all three conditions, maximal forces were exerted with a 20° zone between about 15° and 35° forward of vertical. Subjective comfort preferences, expressed by 86 pilots, closely paralleled the force findings. It is concluded that aircraft brake-pedal systems should be designed to maximize the effectiveness of the foot in that optimal zone, and that the same zone should be considered for other foot-operated controls, like automobile accelerator pedals.

Title	Authors	Report Number and Date
The Role of Anthropology in High Altitude Flight	Alexander, Garrett & Robinette	Aerospace Medicine, 42(4), 388-393, 1971

ABSTRACT: For 25 years USAF anthropologists have conducted research on the spatial requirements of man in high altitude aircraft and space flight systems. Each man-machine problem has many facets and AMRL's Anthropology Branch has attempted to gather applicable anthropological data, whether the problem be one of workspace layout, ejection or escape mechanisms, protective equipment for hostile environments or performance decrements due to combinations of restraint equipment. This paper reflects some of this pertinent research.

Title	Authors	Report Number and Date
An Introduction to Relaxed Hand Anthropometry	Garrett	AMRL-TR-67-217, August 1971

ABSTRACT: Anthropometric data comparing the length of the relaxed hand with the flat, straightened hand are presented. The correlation coefficient between the hand length in the two positions is not high.

Title	Authors	Report Number and Date
Ground Areas Visible From the Aircraft Cockpit Eye Position: A Method of Evaluation	Kennedy	AMRL-TR-68-164, November 1968 (AGARD Conf. Proc. No. 55, Problems of the Cockpit Environment, Amsterdam, Netherlands, November 1968

ABSTRACT: The purpose of this research is to develop a realistic and objective method for comparing aircraft in terms of the ground areas visible from their cockpits. The method consists of calculating the area of the earth's surface visible from the pilot's eye position, within a radius of 3,000 feet and of 18,000 feet. The ground area visible, expressed as a percentage, may be regarded as an index of the visibility from the cockpit. A camera, which produces superimposed pictures from two lenses separated by the average interpupillary distance, is located at the cockpit-design eye position and the photograph obtained shows a panorama of what the pilot could see if he rotated his head from side to side. To illustrate that only part of the terrain beneath the aircraft is visible from the design-eye position, angular coordinates describing the outlines of obstacles to vision are projected to the ground. Through simple trigonometric analysis, the location of the points where these vectors "strike" the ground are calculated relative to ground "0", a point on the ground directly below the aircraft. Once all necessary points are determined and plotted, it is possible to define the areas on the surface of the earth that are visually inaccessible from the cockpit-design eye position.

Title	Authors	Report Number and Date
Anthropological Applications in High Altitude Flight Systems	Alexander, Garrett & Robinette	AMRL-TR-70-3, March 1970

ABSTRACT: Anthropologists can provide data describing the human body as comprehensively as necessary, whether as naked flesh or encumbered with protective equipment from head to toe. This article reflects only some of the research programs pursued in the Anthropology Branch on various phases of the dimensional requirements of the pressure suited man in the man-machine system. The spatial requirements for the man in a cockpit or capsule and on ejection and escape mechanisms or wearing clothing as protection against hostile environmental factors, such as heat, cold, vacuum, high g, and radiation, present separate problems for the design engineer that can be helped effectively with the applicable anthropological data.

Title	Authors	Report Number and Date
Seating in Plant and Office	Kroemer	American Industrial Hygiene Assn. Journal 32:10, 633-652, 1971 (Also published as AMRL-TR-71-52)

ABSTRACT: Sitting as a working position is less fatiguing than standing and can, therefore, be maintained longer. It is also a more stable posture and allows better control of motions. Based on anthropometric and biomechanical data, design aspects of work seats as well as of foot rests, office equipment, consoles, work benches, machine stands, and the like are discussed. Recommended dimensions for such work stations are presented.

Title	Authors	Report Number and Date
Pedal Operation by the Seated Operator	Kroemer	SAE Preprint 720004. New York, NY: Society of Automotive Engineers, 1972. (Also published as AMRL-TR-71-102)

ABSTRACT: This paper attempts to serve three purposes: 1) to summarize the open scientific literature on muscular force applicable to pedals, and on the efficiency of foot motions on or between pedals, depending on the body support and the body posture of the seated operator, 2) to discuss the applicability of such studies in automobile (or other equipment) design, especially to the design, selection, and arrangement of foot-operated controls, and 3) to point out that for most conventional vehicles and equipment, modes of seating and of pedal arrangement and operation follow largely common experience and tradition, and only partly scientific findings. For new man-machine systems, new solutions seem possible.

Title	Authors	Report Number and Date
Human Force Exertions in Aircraft Control Locations	Thordsen, Kroemer & Laubach	AMRL-TR-71-119, 1972

ABSTRACT: Experiments were conducted to measure the maximum isometric forces which male subjects could exert at six locations of hand operated aircraft controls. Forces were measured in two vertical and four to eight horizontal directions. The subjects (N=51) sat in a simulated aircraft seat and exerted forces on a cylindrical handle. Selected anthropometric dimensions were obtained on the subjects and compared

with those from the 1967 USAF anthropometric survey of flying personnel. Summary statistics including the mean, standard error of the mean, standard deviation, standard error of the standard deviation, coefficient of variation, symmetry, kurtosis, and selected percentiles are presented for each of the 44 force exertion measures. An analysis of the magnitude and direction of the force components, recorded in a plane orthogonal to the requested direction, is presented for each of the 44 primary force measurements. The intercorrelations for the 44 exertions, and the correlations between the force exertions and the anthropometric dimensions are presented. Test-retest differences are presented for eleven of the subjects who completed the 44 force exertion measurements on two separate occasions.

Title	Authors	Report Number and Date
The Law and Our Responsibility	Garrett	Human Factors, 14:1, February 1972

ABSTRACT: Social and judicial reluctance to accept defectively designed products raises sharp questions concerning the Human Factors engineers' moral, ethical, legal and personal responsibilities. This paper presents one Human Factors engineer's thoughts and opinions on these questions and illustrates situations where liability perhaps should and should not be personal.

Title	Authors	Report Number and Date
Displacements of a Helmet-Attached Reticle Under g-Forces	Kennedy & Kroemer	To be published in Aerospace Medicine

ABSTRACT: Thirteen subjects were submitted to centrifuge runs and exposed to g_z vectors between +1 and +6g. The subjects wore two types of individually fitted helmets, the GENTEX type DH 129-2 (G) and the HGU-2A/P (H) helmets. To the top and each side of the helmets, masses weighing up to 20 ounces each were attached in a variety of combinations of total amount, with symmetrical and assymmetrical distributions. All assymmetrical mass distributions were offset to the subject's left side. Rigidly attached to the helmet was a light-weight reticle with its cross-hair 1-1/4 to 1-1/2 inches in front of the subject's left eye.

Reticle displacements due to $+g_z$ forces were photographed, measured and recorded with respect to the subject's pupil in lateral (Y) and in vertical (Z) directions. After corrections were made for the subject's involuntary head pitch and yaw movements, the reticle displacements can be generally described as follows: mean Y displacements for both helmets were predominately to the subject's left side, although for three assymmetrical loads, the G helmet permitted movements to the subject's right.

Reticle movements for the G helmet ranged from 2.5 mm right to 3.5 mm left; for the H helmet, less than 0.5 mm right to 5 mm left. With the few exceptions noted, there is no discernible relationship between total mass load or distribution and direction or amount of movement. However, the H helmet permitted more consistent movements to the left, while with the G helmet, there were three assymmetrical loadings demonstrating consistent movements to the right. Essentially all lateral movement occurred at the +2 g_z level. Accelerations higher than +2 g_z had no demonstrable additional effect on movements of the reticle in this direction.

Z displacements were in the same direction as the g_z vector and were generally proportional with the magnitude of g_z. The mean depressions of the reticle ranged from about 9 to 24 mm (0.4 to 1 inch) at +6 g_z. The recorded movements do not indicate any obvious systematic relationships to helmet type or loading. After return to the +1 g_z condition, the reticle generally was not automatically relocated to its original +1 g_z position, but remained a mean displacement of 3 to 5 mm (0.1 to 0.2 inches) below the pupil.

Title	Authors	Report Number and Date
Involuntary Head Movements, and Helmet Motions During Centrifuge Runs of up to 6 g_z	Kroemer & Kennedy	To be published in Aerospace Medicine

ABSTRACT: Open-loop centrifuge runs reaching +6 g_z were performed with 13 subjects wearing two different types of helmets: the foam padded standard HGU-2A/P, and the Gentex 129-2 with adjustable web suspension. Weights up to 20 ounces were attached at top and sides. The total maximal load was limited to 40 ounces and the largest lateral off-balance to 15 ounces.

During the centrifuge runs, each subject attempted to maintain his gaze at a target directly in front of him. Hence, no voluntary motion of the head should have occurred. Position of the helmet and of the head were recorded photographically at each g-level. From the photographs, data on actual movements of the head and of the helmet were extracted and subjected to a computer-aided analysis.

Involuntary angular head movements, as well as rotational displacements of the helmet on the head, are discussed in this paper in terms of pitch, roll and yaw. Also described are linear changes in the vertical height of the subjects' eyes. Direction and amount of such motions are discussed with respect to the experimental variables: subjects, magnitude of +g_z, helmet type worn, mass of helmet assembly.

Title	Authors	Report Number and Date
COMBIMAN: COmputerized BIomechanical MAN-model	Kroemer	AMRL-TR-72-16, 1972

ABSTRACT: COMBIMAN is an engineering tool to represent geometry and physics of the man-cockpit system:

1. Reservoir of anthropometric information : "Body Form Analog"
2. Representation of body mechanics : "Biomechanical Analog"
3. Ergonomic model of man at his work station : "Ergonomic Analog"

This paper summarizes a literature review, a general discussion of computer models representing the geometry of the operator at his work station, the concept of the mathematical formulation, and the development phases of COMBIMAN.

Title	Authors	Report Number and Date
Relationships Among Isometric Forces Measured in Aircraft Control Locations	Laubach, Kroemer & Thordsen	To be published in Aerospace Medicine (Also published as AMRL-72-19)

ABSTRACT: Fifty-one male subjects participated in a study designed to measure the maximum ("peak") isometric forces that could be exerted at six locations of hand-operated aircraft controls. The subject sat in a simulated aircraft seat and exerted forces on a cylindrical handle. Forces were measured in two vertical and four to eight horizontal directions. Selected descriptive statistics are presented for each of the 44 force exertion measurements. The results show that the amount of force exertable depends decidedly on the location of the control and on the direction of force exertion. Correlations among the force exertions at the several locations were low, indicating that the forces exertable at a location must be determined experimentally rather than by regression analysis of other force data.

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