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16. Abstract

This report is Volume 3 of the Final Report under Contract DTNH22-80-C-07502, "Development of Anthropometrically Based Design Specifications for an Advanced Adult Anthropomorphic Dummy Family." Volume I describes the collection of data on which the specifications are based as well as the fabrication of surface forms.

The purpose of Volume 3 is to present the anthropometric specifications for small female and large male dummies. Data gathered during the project as well as data available in the literature were used in formulating these specifications. Most of the analytical techniques used in combining the various data resources have been described in Volume 2 which presents the specifications for the mid-sized male dummy. Where techniques and procedures differ, they are included in Volume 3.

The report is supplemented by full-size blueprint nos. SF-201, SF-202, and SF-203 for the small female and nos. LM-301, LM-302, and LM-303 for the large male. These show side, front, and top views of the following: surface landmarks, joint centers, segment centers of gravity, origins of segment coordinate systems, surface profile of actual surface forms, information on anatomical and principal axes, and information on segmentation planes.

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1.0 INTRODUCTION

The purpose of Volume 3 is to present the anthropometric specifications for small female and large male dummies. Data gathered during the project as well as data available in the literature were used in formulating these specifications. Most of the analytical techniques and procedures used in combining the various data resources have been described in Volume 2 which presents the specifications for the mid-sized male dummy. Where techniques and procedures differ, they are included in Volume 2. As in Volumes 1 and 2 the subscripts L, H, and A are used with coordinate axes to indicate the laboratory, the whole body or H-point, and the anatomical or body segment reference systems, respectively.

The report is supplemented by full-size blueprint nos. SF-201, SF-202, and SF-203 for the small female and Nos. LM-301, LM-302, and LM-303 for the large male. These show side, front, and top views of the following:

- Surface landmarks
- Joint centers
- Segment centers of gravity
- Origins of segment coordinate systems
- Surface profile of actual surface form
- Information on anatomical and principal axes
- Information on segmentation planes

2.0 SMALL FEMALE AND LARGE MALE SUBJECT DATA IN HIP POINT COORDINATES

2.1 Development of Standard Seat Coordinate Systems

The same system of surface landmarks has been used to define the small female and large male surface forms as was used for the mid-sized male. These are described in detail in Volume 2.

To locate the hip joints (used to define an H-point which has been selected as the origin of coordinates for the surface form), the data of Reynolds et al. (1981) were again used. For the small female, Reynolds et al. obtained data from two body size cells. Both cells are for short females, but the weights range from light to heavy. The following compares the two cells of Reynolds et al. with the current data.

	Cell 1	Cell 2	Current Study
Weight, kg (lb)	74.8 (165)	46.9 (103)	46.4 (102)
Stature, cm (in)	151.5 (59.6)	153.9 (60.6)	151.1 (59.5)

As should be expected, the match is good with the short, light segment of the population. In that the short height of all subjects generally implies a small frame, the pelvic data were accepted even though they may be slightly too large. No alternative data are known to exist.

Likewise, two body size cells were used for the large male. The two cells are fixed on tall subjects with weight varying widely. The following is a comparison of the two cells with the large male subject group of the current study.

	Cell 3	Cell 6	Current Study
Weight, kg (lb)	91.5 (201.3)	76.1 (167.4)	102.6 (225.8)
Stature, cm (in)	182.8 (72.0)	184.8 (72.8)	186.4 (73.4)

Although somewhat heavy, the large male standing height matches fairly well with the Reynolds et al. sample. Again, it is assumed that the height variable is the more important predictor of skeletal dimensions for the pelvis. Although the Reynolds et al. pelvis data may be somewhat small for the large male, there are no known alternatives and it is believed any differences will be small (less than 1 cm).

The direction of the Reynolds et al. coordinate system was superimposed upon the UMTRI data for anterior-superior iliac spine (ilio-spinale summum) and pelvic crest (pubic symphysis). In order to accomplish this, tissue thickness estimates were made for the distances from the surface targets to the underlying bony landmarks in the vehicle-seated posture. The first estimates were made for the mid-sized male. A tissue depth of 5 mm over the anterior-superior iliac spines was estimated from palpation of this point on standing subjects. While the subjects were standing, the overlying tissue is fairly taut across the pelvic spines. However, when they were seated, the abdominal tissue tended to slacken and rest over the pelvic girdle. Therefore, the tissue thickness was much greater in the seated subjects. For photographic determination of the pelvic surface landmarks, the technique used was to palpate the point and place the end of a metal probe rod firmly on the location so that a projection to the landmark could be determined by photometric analysis of calibrated marks on the rod. Because the tissue was effectively pushed out of the way by the probe, the 5-mm tissue thickness estimate was used for pelvic location. Also, because the probe was held within 10° of vertical, the depth to the bone was applied to the Z_L coordinate.

A tissue depth of 15 mm over the pubic symphysis was estimated by palpation in placing the probe and by analysis of general anatomical factors such as muscle attachments in this region. The probe was held within 10° of vertical in the $Y_L Z_L$ plane and 30° of vertical in the $X_L Z_L$ plane. Therefore, with an estimated tissue thickness of 15 mm, the depth to the bone landmark was 13 mm in the Z_L coordinate and 7 mm in the X_L coordinate. These results were scaled for the case of the small

female and large male. The data used to locate points on the pelvis from surface landmark data are summarized as follows:

Surface Landmark	Coordinate	Small Female	Mid-Sized Male	Large Male
ASIS	X_L coord (+ to front)	0	0	0
	Z_L coord (+ up)	-3	- 5	- 7
Symphysis	X_L coord (+ to front)	-5	- 7	-10
	Z_L coord (+ up)	-8	-13	-17

With respect to laboratory coordinates the two coordinate systems made angles of 55.53° (large male) and 48.37° (small female). These compare with the 54.07° for the mid-sized male. Using the resulting coordinate transformation it was possible to obtain the following points needed for construction of joint centers, segmentation planes, anatomical segment axis construction, etc.

- H-points
- Pubic symphysis
- Inferior symphyseal pole
- Superior pole, pubic symphysis
- Ilio-spinale summum
- Ilio-cristale summum
- Inferior tuberosity point
- Posterior point on 1st sacral vertebral body
- Promontorion
- Lateral point on 1st sacral vertebral body
- Pubotuberosity
- Lateral tuberosity point

The key points for development of standard seat coordinate systems for the surface forms were the H-points which, when referred to the original UMTRI laboratory coordinate system, are at:

Form		X_L (mm)	Y_L (mm)	Z_L (mm)
Small Female:	Left	755	699	425
	Right	755	539	425
Large Male:	Left	618	705	409
	Right	618	533	409

The Y_L-shifts from the body centerline where ±80 and 86 mm as reported by Reynolds et al. The centers of the lines connecting the two H-points are at Y_L=619 mm, yielding the origins of the standard seat coordinate systems for the two forms.

2.2 Subject Data Translated to Standard Seat Coordinate System

Tables 1 and 2 present all skeletal and surface landmarks used in the development of the anthropometric specifications for the small female and large male surface forms. The origin of coordinates is the center of a line connecting the H-points.

3.0 BODY SEGMENTATION

The segmentation scheme used for the mid-sized male (and documented in detail in Volume 2) has been adopted for use in developing segmentation plane formulae for the small female and large male specification packages. Using this scheme, it was necessary to quantify a variety of points in addition to those already available in the list of measured surface landmarks. These included:

- Nuchale
- Intersection point on back of surface form of a perpendicular from the center of a line connecting the 10th rib targets to a line connecting the T12 and L5 surface targets
- Intersection point on back of surface form of a perpendicular from the center of a line connecting the iliocristale targets to a line connecting the T12 and L5 surface targets
- Pubotuberosity surface (35 mm lateral from pubic symphysis surface point)
- Shifted ASIS (a point 10 mm lateral to ASIS surface)
- Shifted inferior tuberosity (a point 10 mm lateral to inferior tuberosity point which is projected vertically to the seat surface)

Other than nuchale, these points were obtained directly using geometric construction.

For the small female an estimation of the nuchale location was obtained using the data of Young et al. (1983). In their report, the location of nuchale was given in anatomical coordinates (millimeters) as X_A=-88, Y_A=0, Z_A=-31. In otherwords, nuchale is behind and below the center of a line connecting the tragions which serves as the origin. In addition, the coordinates of the center of a line connecting the infraorbitales are given as X_A=69.8 mm. When this construction is superimposed on the same coordinate direction using the same origin, it is found that the Young et al. (1983) infraorbitale is 9 mm behind that obtained in the current study. Also, the nuchale was projected to be 18 mm behind the surface of the head profile line which was measured directly. If the mismatch between infraorbitales is eliminated by shifting tragion forward, then the nuchale still falls 9 mm behind the

surface of the head. It can be suggested that the nuchale target was measured too far behind tragion in the Young et al. study based on hair thickness and the use of a cap during their photography. Based on this assumption, the nuchale point was moved along the X_L coordinate axis to lie on the surface form. A similar shift was necessary in the case of the large male form. In that case the infraorbitale predicted from the McConville et al. (1980) report was found to be 17 mm behind that measured at UMTRI. Also, the nuchale was 16 mm behind the surface of the dummy form. It appears that there is a discrepancy in tragion locations as measured in the two sets of studies. This issue has also been discussed in Volume 2 on the mid-sized male.

With all the points available, each segmentation plane was computed directly using three points. Tables 3 and 4 show the formulae for the segmentation plans for the small female and large male surface forms.

4.0 DEVELOPMENT OF ANATOMICALLY BASED SEGMENT COORDINATE SYSTEMS

This section of the report summarizes the development of anatomically based coordinate systems for each of the various segments of the body. The coordinate systems which have been constructed are the same as, or very similar to, those which have been reported by McConville et al. (1980) in developing anthropometric relationships of body and body segment moments of inertia. As such, they have been used directly in the presentation of center of mass and inertial data and provide the linkage between the coordinate system defining the principal axes of inertia and the standard coordinate system at the center of the H-points. In order to construct coordinate systems and relate them to the standard system, it was necessary to know three points in the segment. The following three were used:

- One at the origin
- One on an axis
- One in one of the orthogonal planes

The points used for each system are defined in Table 2 of Volume 2. Data used are given in Tables 1 and 2 of this volume. The locations of the origins of the various segment anatomical coordinate systems are given in Tables 5 and 6 for the small female and large male. Tables 7 and 8 give the cosine matrices expressed in degrees for all anatomical axis systems with respect to the hip point coordinate system, while Tables 9 and 10 present the cosine matrices directly.

5.0 VOLUME, MASS, AND INERTIAL PROPERTIES

The basic information for these computations is contained in the reports by McConville et al. (1980) and Young et al. (1983). Specific numbers are given for the distance from the origins of anatomically based segment coordinate systems to centers of volume. In addition, regression formulas have been provided to predict volume and inertial properties of the various segments of the body.

The basic anthropometric data for the small female and large male groups (see Section 3 of Volume 1) have been supplemented by the surface profile data given in Tables 11 and 12. These were measured directly on the clay form before molds and castings for the final surface forms were made. The data from these two resources was then used to select anthropometric variables for use in the regression equations. This task was made more complicated by the difference between the seated postures of the current study and the standing postures which were the basis of the regression equations. Variables selected were similar to those used in the mid-sized male computations (Volume 2).

The predicted volumes and the sum of volumes for the whole body are given in Tables 13 and 14 for the small female and large male surface forms. The values obtained for the left and right sides of the body have been averaged. These calculations are based on a density assumption of 1.0 gm/cm^3. Using this value for density, the resulting total body weights would be overestimated by

Small Female = 3.0 percent
Large Male = 5.4 percent

If a density value of 0.92, as has been proposed by Dempster (1955), is used for the thorax, the predicted values for weight are much closer to subject means, especially for the small female. Because of the apparent overestimation, volume scaling factors were used to yield body segment weights which, when summed, yielded the correct total body weight. For

volume, the large male scale factor was 0.949 based on the 5.4 percent overestimation. For moment of inertia corrections this led to a scale factor of 0.966 using the analog

$$\text{Volume} = 0.949V \sim (.9827\ell)^3$$

The scale factor for the small female was selected as 1.0. This was based on the smaller overestimation of volume and the fact that using Dempster's data (1955), the overestimation can become an underestimation. Clearly, some additional work should be done to better specify segment densities.

Young et al. (1983) and McConville et al. (1980) give the locations of centers of volume in segment anatomical coordinate systems. The assumption has been made that center of volume and center of mass are coincident. These data are provided for average females and males. To take this into account, the data have been scaled down for the small female and scaled up for the large male. The scaling is based on comparisons of anthropometric data on length, depth, height, breadth, etc. for the various segments. As anatomically based coordinate systems are oriented primarily in the same directions as heights, depths, and breadths are measured, this scaling procedure appears reasonable. Tables 15 and 16 give the locations of estimated segment centers of gravity with respect to the whole-body coordinate systems for the small female and large male. Tables 17 and 18 give the locations with respect to the individual segment coordinate system, thus documenting the scaling which was carried out.

The anthropometric variables used in the moment of inertia regression equations are given in Tables 19 and 20 for the two surface forms. The resulting moments of inertia are given in Tables 21 and 22. Both predicted and scaled results are included in the tables.

The principal axes of inertial for each segment have been computed by both Young et al. (1983) and McConville et al. (1980) with respect to segment anatomical coordinate systems. In the present study, these transformations were modified slightly to reflect the body symmetry assumption. Tables 23 and 24 present the principal axes of

inertia with respect to anatomical axes as cosine matrices in degrees while Tables 25 and 26 present the cosine matrices directly. Tables 27 through 30 do the same for the principal axes with respect to the H-point coordinate system.

6.0 JOINT CENTERS

The development of joint centers for the small female and large male was based on the results already obtained for the mid-sized male and presented in Volume 2. Because of the similarity of body posture of the three surface forms, it was possible to scale up for the large male and scale down for the small female. The locations of the resulting joint centers are given in Tables 31 and 32 with respect to H-point coordinates. Tables 33 and 34 list the results in segment coordinates.

Head/Neck. For the head/neck junction, the location is chosen to be the occipital condyles. For the mid-sized male, this point is at $(X_H Z_H) = (-11,-26)$ in head segment coordinates. The scale factor on head length (X_H) and head height (Z_H) is 0.978 for the small female yielding a scaled joint which rounds off to (-11,-25). The location of this point can be transformed to H-point coordinates using the appropriate cosine matrix and translated to the origin using data from the table listing segment origins. Scale factors for the large male are 1.025 on the X_H coordinate and 1.009 on the Z_H coordinate. This yields a scaled condyle point with segment coordinates (-11,-26). Scaled locations for some joints show a greater difference from the mid-sized male.

C7/T1. In this case the C7 and glabella surface landmark data were used to establish the angle required for use in the regression equations given in the torso link study by Snyder et al. (1972). Cervical vector prediction equations were available to predict the distance of the C7 surface marker to the C7/T1 interspace as well as the angle made by the vector connecting C7 to the interspace. The predicted angle to the interspace was used directly. However, the distance to the interspace was scaled.

The following chart shows the scaling used in the torso from C7 to S1.

Quantity	Large Male	Mid-Sized Male	Small Female
Upper torso depth (cm)	13.788	11.912	8.976
Abdominal depth (cm)	31.608	26.948	20.956
C7-T12 vector distance (mm)	376	344	325
T12-L5 vector distance (mm)	158	151	109
Upper torso Z_H scale factor	1.09	1	0.86
Upper torso X_H scale factor	1.16	1	0.75
Abdomen Z_H scale factor	1.05	1	0.72
Abdomen X_H scale factor	1.17	1	0.78

So, the value of 2.99 inches, the distance from the C7 surface marker to the C7/T1 interspace for the mid-sized male, was broken into Z_H and X_H components and scaled to 2.26 inches (57.4 mm) for the small female and 3.45 inches (87.6 mm) for the large male.

T4/T5, T8/T9, T12/L1. Similarly, thorax vector prediction equations were used in estimating the location of these interspaces. These required the availability of T4 and T12 surface markers. The angle between a line connecting these two points and a vertical line served as the reference angle for use in the regression equations. After computation of this angle for the small female and large male forms, the equations were then used to predict the following:

- Distance from T4 to T4/T5 interspace
- Vector direction from T4 to T4/T5 interspace
- Distance from T8 to T8/T9 interspace
- Vector direction from T8 to T8/T9 interface
- Distance from T12 to T12/L1 interspace
- Vector direction from T12 to T12/L1 interspace

In each case the predicted distance was broken into components and scaled for large male or small female.

L5/S1. The same procedure was adopted for definition of the L5/S1 joint as has been used for the mid-sized male. This was to choose a point on the centerline of the body with X_H and Z_H coordinates the same as the lateral point on the first sacral vertebral body. These values were taken directly from the pelvis skeletal reconstruction discussed in Section 2 and presented in Tables 1 and 2.

L2/L3. As in the case of the mid-sized male, this joint was selected to be 60 percent of the distance along a line connecting L5/S1 with T12/L1.

Sternoclavicular. For the mid-sized male, this point was estimated to be one centimeter below and two centimeters lateral from the body centerline. Scaling for this point is based on the Y_H values for the acromion points or 0.84 for the small female and 1.02 for the large male.

Claviscapular. For the mid-sized male, this point was estimated from a definition by Dempster (1955) and measurements on bony material to be the following distances from the acromio-clavicular articulation landmark.

- ΔY_H = 27.5/2 mm toward the center of the body
- ΔX_H = 15 mm toward the rear of the body
- ΔZ_H = 10 mm down

The scale factor based on biacromial diameter developed for the sternoclavicular joint was also used for this joint.

Glenohumeral. The glenohumeral joint center for the mid-sized male was based on a reconstruction of skeletal material (the humerus) in three-dimensional space using tissue thickness estimates and three surface landmarks (greater tubercle of the humerus, lateral humeral epicondyle, and medial humeral epicondyle). This point is more or less fixed with respect to the scapula, and as such, with respect to the acromion. To estimate the glenohumeral joint center for the small female and large male, the mid-sized male vector from acromion to this joint was scaled by the factor used for the sternoclavicular and claviscapular joints.

Elbow. This point was computed directly for both the small female and large male as the midpoint of a line between the medial humeral epicondyle and a point 8 mm above the radiale. The "8 mm" point was estimated to be along a line connecting radiale with ulnar styloid for the seated occupants.

Wrist. The reconstruction of the wrist joint was based on the definitions used for the mid-sized male. The dimensions used were scaled based on radius length for the two forms (0.84 for the small female and 1.07 for the large male).

Hip. The hip joints are the H-points discussed earlier and given in Tables 1 and 2.

Knee. The knee joints were computed directly as the center of a line connecting the medial and lateral femoral epicondyle.

Ankle. The ankle joint has been defined for the mid-sized male as the midpoint of a line between the tip of the lateral malleolus of the fibula and a point 5 mm distal to the tibial malleolus. In order to obtain the "5 mm" point, the sphyrion was shifted down the leg a resultant of 5 mm for the seated subjects.

TABLE 1

SURFACE LANDMARKS RELATIVE TO H-POINT (mm):
SMALL FEMALE

Landmark	X_H	Y_H	Z_H
HEAD			
Glabella	- 90	0	578
Infraorbitale (L)	-103	32	550
Infraorbitale (R)	-103	- 32	550
Tragion (L)	-180	67	545
Tragion (R)	-180	- 67	545
Gonion (L)	-167	55	484
Gonion (R)	-167	- 55	484
Gnathion	- 91	0	465
Nuchale*	-247	0	517
TORSO			
Suprasternale	-144	0	391
Mesosternale	-110	0	353
Substernale	- 89	0	316
Nipple (L)	- 39	85	250
Nipple (R)	- 39	- 85	250
10th Rib, anterior, midline	- 10	0	150
Umbilicus	1	0	141
Maximum Abdominal Protrusion	22	0	129
10th Rib (L)	- 96	129	125
10th Rib (R)	- 96	-129	125
VERTEBRAL COLUMN			
C7	-238	0	445
T4	-259	0	364
T8	-247	0	242
T12	-200	0	122
L2	-180	0	79
L5	-154	0	23
Mid-Spine 10th Rib	-201	0	126
Intersection point on back of surface form of a perpendicular from center of line connecting 10th rib targets to line connecting T12 and L5 surface targets*	-183	0	85
Intersection point on back of surface form of a perpendicular from center of line connecting iliocristale targets to line connecting T12 and L5 surface targets*	-165	0	48

TABLE 1
SURFACE LANDMARKS RELATIVE TO H-POINT (mm):
SMALL FEMALE (Continued)

Landmark	X_H	Y_H	Z_H
ARM			
Lateral Humeral Epicondyle (L)	12	211	206
Lateral Humeral Epicondyle (R)	12	-211	206
Radiale (L)	28	207	193
Radiale (R)	28	-207	193
Medial Humeral Epicondyle (L)	15	150	190
Medial Humeral Epicondyle (R)	15	-150	190
Olecranon (L)	34	183	177
Olecranon (R)	34	-183	177
Ulnar Styloid (L)	130	182	383
Ulnar Styloid (R)	130	-182	383
Stylion (L)	121	136	387
Stylion (R)	121	-136	387
LEG AND FOOT			
Lateral Femoral Epicondyle (L)	360	119	72
Lateral Femoral Epicondyle (R)	360	-119	72
Medial Femoral Epicondyle (L)	365	32	69
Medial Femoral Epicondyle (R)	365	- 32	69
Tibiale (L)	378	35	58
Tibiale (R)	378	- 35	58
Patella (L)	404	81	91
Patella (R)	404	- 81	91
Sphyrion (L)	599	57	-172
Sphyrion (R)	599	- 57	-172
Metatarsal-Phalangeal I (L)	698	76	-120
Metatarsal-Phalangeal I (R)	698	- 76	-120
Digit II (L)	729	126	- 74
Digit II (R)	729	-126	- 74
Metatarsal-Phalangeal V (L)	683	157	-147
Metatarsal-Phalangeal V (R)	683	-157	-147
Lateral Malleolus (L)	584	115	-194
Lateral Malleolus (R)	584	-115	-194
Posterior Calcaneus (heel point) (L)*	618	90	-254
Posterior Calcaneus (heel point) (R)*	618	- 90	-254

*Landmark determined by construction.

TABLE 2

SURFACE LANDMARKS RELATIVE TO H-POINT (mm):
LARGE MALE

Landmark	X_H	Y_H	Z_H
HEAD			
Glabella	-111	0	684
Infraorbitale (L)	-128	37	650
Infraorbitale (R)	-128	- 37	650
Tragion (L)	-212	83	646
Tragion (R)	-212	- 83	646
Gonion (L)	-195	70	576
Gonion (R)	-195	- 70	576
Gnathion	-108	0	555
Nuchale*	-293	0	612
TORSO			
Suprasternale	-162	0	459
Mesosternale	-119	0	415
Substernale	- 89	0	364
Nipple (L)	- 59	132	320
Nipple (R)	- 59	-132	320
10th Rib, anterior, midline	33	0	218
Umbilicus	60	0	172
Maximum Abdominal Protrusion	75	0	153
10th Rib (L)	-126	194	143
10th Rib (R)	-126	-194	143
VERTEBRAL COLUMN			
C7	-300	0	531
T4	-333	0	421
T8	-327	0	284
T12	-283	0	155
L2	-246	0	95
L5	-202	0	19
Mid-Spine 10th Rib	-277	0	144
Intersection point on back of surface form of a perpendicular from center of line connecting R10 targets to line connecting T12 and L5 surface targets*	-237	0	77
Intersection point on back of surface form of a perpendicular from center of line connecting iliocristale targets to line connecting T12 and L5 surface targets*	-217	0	44

TABLE 2
SURFACE LANDMARKS RELATIVE TO H-POINT (mm):
LARGE MALE (Continued)

Landmark	X_H	Y_H	Z_H
PELVIS (SURFACE)			
Trochanterion (UMTRI photo) (L)	- 34	217	33
Trochanterion (UMTRI photo) (R)	- 34	-217	33
Iliocristale (L)	-114	197	105
Iliocristale (R)	-114	-197	105
Anterior-Posterior Iliac Spine (L)	- 27	121	86
Anterior-Posterior Iliac Spine (R)	- 27	-121	86
Pubic Symphysis	50	0	50
Thigh-Abdominal Junction (L)	19	155	94
Thigh-Abdominal Junction (R)	19	-155	94
Trochanterion (Skeletal reconstruction)*	22	±215	- 22
Inferior Tuberosity Point*	42	± 51	-115
Pubotuberosity*	50	± 35	50
PELVIS (SKELETAL)			
Pubic Symphysis	40	0	33
H-Point	0	± 86	0
Inferior Symphyseal Pole	43	± 4	- 6
Left Superior Pole, Pubic Symphysis	38	± 5	37
Ilio-Spinale Summum	- 27	±115	79
Iliocristale Summum	-107	±125	74
Inferior Tuberosity Point*	42	± 41	- 62
Posterior Point, 1st Sacral Vertebral Body	-105	0	34
Promontorion	- 73	0	41
Lateral Point, 1st Sacral Vertebral Body	- 93	± 28	42
SHOULDER			
Clavicale (L)	-171	25	473
Clavicale (R)	-171	-25	473
Acromio-Clavicular Articulation (L)	-247	192	480
Acromio-Clavicular Articulation (R)	-247	-192	480
Greater Tubercle Humerus (L)	-185	223	469
Greater Tubercle Humerus (R)	-185	-223	469
Acromion (L)	-256	217	454
Acromion (R)	-256	-217	454
Anterior Scye (L)	-115	167	421
Anterior Scye (R)	-115	-167	421
Posterior Scye (L)	-245	221	328
Posterior Scye (R)	-245	-221	328
Superior Margin Scapula (L)	-331	83	446
Superior Margin Scapula (R)	-331	- 83	446
Inferior Margin Scapula (L)	-301	147	271
Inferior Margin Scapula (R)	-301	-147	271

TABLE 2
SURFACE LANDMARKS RELATIVE TO H-POINT (mm):
LARGE MALE (Continued)

Landmark	X_H	Y_H	Z_H
ARM			
Lateral Humeral Epicondyle (L)	34	266	270
Lateral Humeral Epicondyle (R)	34	-266	270
Radiale (L)	52	261	252
Radiale (R)	52	-261	252
Medial Humeral Epicondyle (L)	27	189	236
Medial Humeral Epicondyle (R)	27	-189	236
Olecranon (L)	48	234	225
Olecranon (R)	48	-234	225
Ulnar Styloid (L)	262	197	398
Ulnar Styloid (R)	262	-197	398
Stylion (L)	245	138	414
Stylion (R)	245	-138	414
LEG AND FOOT			
Lateral Femoral Epicondyle (L)	411	207	157
Lateral Femoral Epicondyle (R)	411	-207	157
Medial Femoral Epicondyle (L)	414	98	175
Medial Femoral Epicondyle (R)	414	- 98	175
Tibiale (L)	433	97	163
Tibiale (R)	433	- 97	163
Patella (L)	460	168	202
Patella (R)	460	-168	202
Sphyrion (L)	721	63	-131
Sphyrion (R)	721	- 63	-131
Metatarsal-Phalangeal I (L)	845	85	- 70
Metatarsal-Phalangeal I (R)	845	- 85	- 70
Digit II (L)	889	150	- 14
Digit II (R)	889	-150	- 14
Metatarsal-Phalangeal V (L)	832	187	-105
Metatarsal-Phalangeal V (R)	832	-187	-105
Lateral Malleolus (L)	711	135	-169
Lateral Malleolus (R)	711	-135	-169
Posterior Calcaneus (heel point) (L)*	741	97	-238
Posterior Calcaneus (heel point) (R)*	741	- 97	-238

*Landmark determined by construction.

TABLE 3

FORMULATION OF SEGMENTATION PLANES: SMALL FEMALE

Head:	$.38133X_H + .92444Z_H - 383.75 = 0$
Neck:	$.70711X_H + .70711Z_H - 177.48 = 0$ (for all $X_H \geq -194$)
Thorax:	$.41773X_H - .90857Z_H + 153.67 = 0$
Abdomen:	$.42046X_H - .90731Z_H + 112.93 = 0$
Hip:	$-.79326X_H \pm .60868Y_H + .01568Z_H + 55.706 = 0$ (+ sign on Y_H for right side of body)
Knee:	$-.95067X_H + .31022Z_H + 319.90 = 0$
Ankle:	$.74130X_H - .67118Z_H - 519.21 = 0$
Shoulder:	$.37621X_H \pm .92649Y_H - .00936Z_H - 77.411 = 0$ (+ sign on Y_H for left side of body)
Elbow:	$-.71664X_H \pm .14376Y_H - .68246Z_H + 118.85 = 0$ (+ sign on Y_H for left side of body)

TABLE 4

FORMULATION OF SEGMENTATION PLANES: LARGE MALE

Head:	$.34482X_H + .93867Z_H - 473.43 = 0$
Neck:	$.70711X_H + .70711Z_H - 213.55 = 0$
Thorax:	$.51108X_H - .85954Z_H + 187.31 = 0$
Abdomen:	$.50957X_H - .86043Z_H + 148.44 = 0$
Hip:	$-.78392X_H \pm .62046Y_H - .02216Z_H + 62.020 = 0$ (+ sign on Y_H for right side of body)
Knee:	$-.97780X_H + .20953Z_H + 368.98 = 0$
Ankle:	$.69191X_H - .72199Z_H - 593.44 = 0$
Shoulder:	$.34605X_H \pm .93630Y_H + .05993Z_H - 141.80 = 0$ (+ sign on Y_H for left side of body)
Elbow:	$-.84192X_H \pm .28017Y_H - .46117Z_H + 78.614 = 0$ (+ sign on Y_H for left side of body)

TABLE 5

LOCATION OF ORIGIN OF SEGMENT ANATOMICAL COORDINATE SYSTEMS: SMALL FEMALE

Segment	X_H (mm)	Y_H (mm)	Z_H (mm)
Head	-180	0	545
Neck	-238	0	445
Thorax	-183	0	85
Abdomen	- 96	0	125
Pelvis	- 15	0	75
Upper Arms	-206	±171*	376
Lower Arms	28	±207	193
Upper Legs	18	±190	- 18
Lower Legs	378	± 35	58
Feet	695	±115	-126

*Positive sign on Y_H for left side of body.

TABLE 6

LOCATION OF ORIGIN OF SEGMENT ANATOMICAL COORDINATE SYSTEMS: LARGE MALE

Segment	X_H (mm)	Y_H (mm)	Z_H (mm)
Head	-212	0	646
Neck	-300	0	531
Thorax	-237	0	77
Abdomen	-126	0	143
Pelvis	- 27	0	86
Upper Arms	-256	±217*	454
Lower Arms	52	±261	252
Upper legs	22	±215	- 22
Lower Legs	433	± 97	163
Feet	843	±134	- 80

*Positive sign on Y_H for left side of body.

TABLE 7

ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM: SMALL FEMALE
(Cosine Matrix Expressed in Degrees)

Segment		X_H	Y_H	Z_H
Head	X_A	3.7	90.0	86.3
	Y_A	90.0	0.0	90.0
	Z_A	93.7	90.0	3.7
Neck	X_A	27.5	90.0	117.6
	Y_A	90.0	0.0	90.0
	Z_A	62.4	90.0	27.5
Thorax	X_A	8.7	90.0	81.3
	Y_A	90.0	0.0	90.0
	Z_A	98.7	90.0	8.7
Abdomen	X_A	24.7	90.0	65.3
	Y_A	90.0	0.0	90.0
	Z_A	114.7	90.0	24.7
Pelvis	X_A	53.9	90.0	36.1
	Y_A	90.0	0.0	90.0
	Z_A	143.9	90.0	53.9
Upper Arm (L)	X_A	51.3	99.7	40.4
	Y_A	90.4	12.8	77.2
	Z_A	141.3	98.2	52.5
Upper Arm (R)	X_A	51.3	80.3	40.4
	Y_A	89.6	12.8	102.8
	Z_A	141.3	81.8	52.5
Lower Arm with Hand (L)	X_A	148.2	78.0	61.1
	Y_A	76.2	13.8	90.0
	Z_A	118.0	83.4	151.1
Lower Arm with Hand (R)	X_A	148.2	102.0	61.1
	Y_A	103.8	13.8	90.0
	Z_A	118.0	96.6	151.1
Upper Leg (L)	X_A	105.3	92.8	15.5
	Y_A	79.8	11.7	84.4
	Z_A	161.5	78.6	104.4
Upper Leg (R)	X_A	105.3	87.2	15.5
	Y_A	100.2	11.7	95.6
	Z_A	161.5	101.4	104.4

TABLE 7
ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM:
SMALL FEMALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_A	50.4	65.7	49.3
	Y_A	109.9	24.7	103.9
	Z_A	133.7	93.9	44.0
Lower Leg (R)	X_A	50.4	114.3	49.3
	Y_A	70.1	24.7	76.1
	Z_A	133.7	86.1	44.0
Foot (L)	X_A	59.5	80.3	32.3
	Y_A	94.4	9.6	98.7
	Z_A	149.1	89.3	59.1
Foot (R)	X_A	59.5	99.7	32.3
	Y_A	85.6	9.6	81.3
	Z_A	149.1	90.7	59.1

TABLE 8

ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM: LARGE MALE
(Cosine Matrix Expressed in Degrees)

Segment		X_H	Y_H	Z_H
Head	X_A	2.7	90.0	87.3
	Y_A	90.0	0.0	90.0
	Z_A	92.7	90.0	2.7
Neck	X_A	24.2	90.0	114.2
	Y_A	90.0	0.0	90.0
	Z_A	65.8	90.0	24.2
Thorax	X_A	7.9	90.0	82.1
	Y_A	90.0	0.0	90.0
	Z_A	97.9	90.0	7.9
Abdomen	X_A	30.7	90.0	59.3
	Y_A	90.0	0.0	90.0
	Z_A	120.7	90.0	30.7
Pelvis	X_A	64.9	90.0	25.1
	Y_A	90.0	0.0	90.0
	Z_A	154.9	90.0	64.9
Upper Arm (L)	X_A	57.3	112.4	41.4
	Y_A	84.5	23.9	66.8
	Z_A	146.7	98.1	58.0
Upper Arm (R)	X_A	57.3	67.6	41.4
	Y_A	95.5	23.9	113.2
	Z_A	146.7	81.9	58.0
Lower Arm with Hand (L)	X_A	117.3	69.3	35.4
	Y_A	66.8	25.4	99.8
	Z_A	142.8	76.0	123.6
Lower Arm with Hand (R)	X_A	117.3	110.7	35.4
	Y_A	113.2	25.4	80.2
	Z_A	142.8	104.0	123.6
Upper Leg (L)	X_A	114.3	82.1	25.7
	Y_A	85.7	8.0	96.7
	Z_A	155.3	88.9	114.7
Upper Leg (R)	X_A	114.3	97.9	25.7
	Y_A	94.3	8.0	83.3
	Z_A	155.3	91.1	114.7

TABLE 8
ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM:
LARGE MALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_A	47.7	65.4	52.3
	Y_A	104.2	25.1	110.2
	Z_A	134.2	85.3	44.6
Lower Leg (R)	X_A	47.7	114.6	52.3
	Y_A	75.8	25.1	69.8
	Z_A	134.2	94.7	44.6
Foot (L)	X_A	57.8	79.0	34.4
	Y_A	92.3	11.8	101.5
	Z_A	147.7	85.8	58.1
Foot (R)	X_A	57.8	101.0	34.4
	Y_A	87.7	11.8	78.5
	Z_A	147.7	94.2	58.1

TABLE 9

ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM: SMALL FEMALE
(Cosine Matrix)

Segment		X_H	Y_H	Z_H
Head	X_A	.998	0.000	.0649
	Y_A	.000	1.000	.000
	Z_A	-.0649	0.000	.998
Neck	X_A	.887	0.000	-.463
	Y_A	.000	1.000	.000
	Z_A	.463	0.000	.887
Thorax	X_A	.989	0.000	.151
	Y_A	.000	1.000	.000
	Z_A	-.151	0.000	.989
Abdomen	X_A	.909	0.000	.418
	Y_A	.000	1.000	.000
	Z_A	-.418	0.000	.909
Pelvis	X_A	.589	0.000	.808
	Y_A	.000	1.000	.000
	Z_A	-.808	0.000	.589
Upper Arm (L)	X_A	.625	-0.169	.762
	Y_A	-.006	0.975	.222
	Z_A	-.780	-0.143	.609
Upper Arm (R)	X_A	.625	0.169	.762
	Y_A	.0062	0.975	-.222
	Z_A	-.780	0.143	.609
Lower Arm with Hand (L)	X_A	-.850	0.208	.484
	Y_A	.238	0.971	-.000
	Z_A	-.470	0.115	-.875
Lower Arm with Hand (R)	X_A	-.850	-0.208	.484
	Y_A	-.238	0.971	.000
	Z_A	-.470	-0.115	-.875
Upper Leg (L)	X_A	-.264	-0.048	.963
	Y_A	.178	0.979	.098
	Z_A	-.948	0.197	-.250
Upper Leg (R)	X_A	-.264	0.048	.963
	Y_A	-.178	0.979	-.098
	Z_A	-.948	-0.197	-.250

TABLE 9
ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM:
SMALL FEMALE (Cosine Matrix, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_A	.637	0.412	.652
	Y_A	-.341	0.909	-.241
	Z_A	-.691	-0.069	.719
Lower Leg (R)	X_A	.637	-0.412	.652
	Y_A	.341	0.909	.241
	Z_A	-.691	0.069	.719
Foot (L)	X_A	.508	0.169	.845
	Y_A	-.076	0.986	-.152
	Z_A	-.858	0.013	.514
Foot (R)	X_A	.508	-0.169	.845
	Y_A	.076	0.986	.152
	Z_A	-.858	-0.013	.514

TABLE 10

ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM: LARGE MALE
(Cosine Matrix)

Segment		X_H	Y_H	Z_H
Head	X_A	.999	0.000	.0476
	Y_A	.000	1.000	.000
	Z_A	-.0476	0.000	.999
Neck	X_A	.912	0.000	-.410
	Y_A	.000	1.000	.000
	Z_A	.410	0.000	.912
Thorax	X_A	.991	0.000	.137
	Y_A	.000	1.000	.000
	Z_A	-.137	0.000	.991
Abdomen	X_A	.860	0.000	.511
	Y_A	.000	1.000	.000
	Z_A	-.511	0.000	.860
Pelvis	X_A	.424	0.000	.906
	Y_A	.000	1.000	.000
	Z_A	-.906	0.000	.424
Upper Arm (L)	X_A	.540	-0.380	.750
	Y_A	.096	0.914	.394
	Z_A	-.836	-0.141	.530
Upper Arm (R)	X_A	.540	0.380	.750
	Y_A	-.096	0.914	-.394
	Z_A	-.836	0.141	.530
Lower Arm with Hand (L)	X_A	-.459	0.353	.815
	Y_A	.394	0.903	-.170
	Z_A	-.797	0.243	-.554
Lower Arm with Hand (R)	X_A	-.459	-0.353	.815
	Y_A	-.394	0.903	.170
	Z_A	-.797	-0.242	-.554
Upper Leg (L)	X_A	-.412	0.137	.901
	Y_A	.074	0.990	-.117
	Z_A	-.908	0.019	-.418
Upper Leg (R)	X_A	-.412	-0.137	.901
	Y_A	-.074	0.990	.117
	Z_A	-.908	-0.019	-.418

TABLE 10
ANATOMICAL AXES WITH RESPECT TO HIP POINT AXIS SYSTEM:
LARGE MALE (Cosine Matrix, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_A	.673	0.416	.611
	Y_A	-.246	0.906	-.346
	Z_A	-.697	0.082	.712
Lower Leg (R)	X_A	.673	-0.416	.611
	Y_A	.246	0.906	.346
	Z_A	-.697	-0.082	.712
Foot (L)	X_A	.532	0.190	.825
	Y_A	-.040	0.979	-.200
	Z_A	-.846	0.073	.529
Foot (R)	X_A	.532	-0.190	.825
	Y_A	.040	0.979	.200
	Z_A	-.846	-0.073	.529

TABLE 11

COORDINATES OF SURFACE POINTS ON CLAY FORM: SMALL FEMALE

Line	Selected Point	X_H	Y_H	Z_H
BODY CENTERLINE	Crotch	69	0	25
		67	0	47
		63	0	63
		59	0	76
		53	0	89
		45	0	102
		38	0	113
		28	0	125
		16	0	134
	Umbilicus	2	0	140
		- 15	0	157
		- 27	0	172
		- 37	0	188
		- 44	0	203
		- 52	0	219
		- 59	0	236
		- 66	0	253
		- 73	0	274
		- 79	0	293
		- 86	0	312
		- 96	0	332
		-106	0	348
		-116	0	360
		-126	0	370
		-136	0	383
		-145	0	392
	Suprasternale	-152	0	400
		-152	0	416
		-152	0	433
	Back of Chin (neck)	-150	0	445
	Under Chin, Front	-103	0	457
	Front of Chin, Low	- 91	0	467
	Lower Lip (mid)	- 87	0	496
	Top Lip (mid)	- 85	0	506
	Root of Nose	- 89	0	518
	Tip of Nose	- 73	0	531
	Nasion	- 89	0	578
		- 90	0	593
		- 93	0	610
		-102	0	629
		-112	0	642
		-130	0	654
		-147	0	661
		-175	0	667

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
Centerline (Continued)	Top of Head	-185	0	667
		-200	0	666
		-225	0	658
		-249	0	643
		-266	0	618
		-273	0	595
		-272	0	575
		-268	0	553
		-255	0	527
		-240	0	507
		-235	0	488
		-235	0	467
		-236	0	449
		-243	0	432
		-247	0	412
		-253	0	392
		-259	0	372
	Edge of Seatback	-272	0	363
BACK OF SHOULDER TO BELOW BREAST	Rear of Shoulder	-264	75	373
		-254	80	392
		-241	84	405
		-233	85	417
	Top of Shoulder	-226	86	418
		-192	84	407
		-172	80	393
	Clavicle	-164	77	388
		-147	74	378
		-125	73	361
		-107	76	341
		- 87	79	318
		- 70	81	294
		- 55	82	274
		- 41	83	257
	Tip of Breast	- 39	85	250
		- 39	83	232
		- 42	81	217
		- 46	78	208
	Base of Breast	- 53	75	204

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
TOP OF SHOULDER TO HAND	Top of Shoulder	-188	150	400
		-165	153	394
		-145	157	384
		-123	160	366
		-103	164	345
		- 88	168	325
		- 67	173	309
		- 45	176	289
		- 24	178	272
	Crook of Elbow	5	181	248
		20	178	269
		32	175	284
		47	172	301
		63	170	322
		82	167	347
		95	163	368
		107	157	388
	Wrist	114	153	403
		172	148	423
	At Hand	132	140	454
TOP OF HEAD TO LATERAL SHOULDER	Top of Head	-185	0	667
		-184	19	665
		-182	41	656
		-181	57	643
		-180	68	622
		-179	73	598
		-174	70	579
	Front of Ear	-169	66	556
	Bottom of Ear, Front	-165	63	519
	Jaw	-163	52	481
	Behind Ear, Down Neck	-194	54	508
		-199	46	479
		-206	48	450
	Back of Neck	-212	56	433
		-214	80	420
		-215	105	413
		-209	131	404
		-202	156	396
	Lateral Shoulder	-186	179	382

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
SIDE OF ARM TO WRIST	Shoulder	-169	193	358
		-147	199	336
		-128	201	316
		-105	203	295
		- 83	204	272
		- 55	208	252
		- 28	212	232
	Lateral Humeral Epicondyle (bend of elbow)	5	212	207
		25	214	226
		44	212	245
		64	208	266
		83	202	291
		97	193	321
		110	187	348
	Ulnar Styloid	129	183	382
		146	179	403
		166	184	427
UNDERSIDE OF ARM	Anterior Scye (close)	-165	162	272
		-147	165	255
		-124	168	239
		-102	168	224
		- 81	170	213
		- 64	172	202
		- 44	176	188
		4	181	174
	Low Point on Elbow	34	186	177
		56	183	199
		77	179	225
		91	176	253
		103	173	289
		111	170	311
		119	169	327
		130	166	356
	Ulnar Styloid	139	165	370
		162	159	402
FLANK	Posterior Scye (close)	-191	164	285
		-186	149	260
		-171	141	225
		-189	135	191
		-145	130	164
		-128	130	132
		-112	135	100
		- 98	142	77
		- 81	150	55

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
Flank (Continued)		- 61	162	32
		- 40	177	7
	Near Seat	5	188	- 15
INSIDE ARM	Scye	-104	131	357
		- 88	136	285
		- 59	139	262
		- 29	142	237
	Humeral Condyle	3	150	213
		27	145	225
		52	146	255
		73	146	295
		91	144	333
		111	140	374
	Wrist	123	135	394
	Thumb Knuckle	142	101	434
OUTSIDE OF LEG		25	188	-11
		62	186	- 4
		102	181	5
	Max. Circ. Pt. Upper Thigh	113	180	5
		142	174	14
		175	165	24
		204	157	30
		238	149	39
		275	141	47
		301	134	52
		337	128	57
	Lateral Femoral Epicondyle	368	121	61
		382	125	40
		397	132	19
	Max. Calf Circ. Pt.	416	138	- 11
		437	138	- 37
		456	137	- 61
		477	132	- 87
		500	125	-110
		525	119	-136
	Min. Ankle Circ. Pt.	548	115	-160
		573	116	-186
	Lateral Malleolus	586	119	-197
		603	122	-210
		626	128	-229
		642	134	-212
		654	139	-194
	Metatarsal Phalangeal V	680	156	-156
		697	163	-131

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
UNDERSIDE OF LEG	Seat-Thigh Juncture	--	--	--
		305	73	- 11
		328	71	1
	Knee Pit	344	76	8
		368	75	- 15
		381	78	- 40
		398	79	- 64
		422	80	- 92
		445	82	-114
		469	81	-128
		502	82	-153
		537	85	-180
		567	86	-205
		576	87	-215
TOP OF LEG	Thigh Abdominal Point	32	109	61
		61	106	65
		96	102	72
		127	92	80
		213	87	98
		245	84	105
		277	83	112
		299	83	116
		328	81	120
	Top of Knee	367	79	172
		387	80	113
	Patella	408	81	133
		430	83	53
		455	87	22
		480	89	- 8
		518	92	- 56
		550	91	- 98
		585	91	-134
		606	91	-143
		632	96	-138
		658	99	-123
		685	104	-103
		715	105	- 77
	Toe I	733	107	- 66
	Toe II	728	128	- 74
	Toe III	722	145	- 86
	Toe IV	717	156	- 99
	Toe V	708	163	-155

TABLE 11
COORDINATES OF SURFACE POINTS ON CLAY FORM:
SMALL FEMALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
INSIDE LEG	Crotch	76	12	- 3
		107	14	4
		147	12	13
		182	19	23
		207	27	32
		242	35	49
		285	35	60
		321	31	69
	Medial Femoral Epicondyle	350	33	74
	Tibiale	373	38	56
		388	42	35
		422	45	- 10
	Max. Calf Circ. Pt.	446	48	- 33
		483	52	- 70
		508	61	- 96
	Ankle	535	64	-124
		575	66	-156
	Sphyrion	592	61	-178
	Arch	626	71	-213
		635	72	-165
	Metatarsal Phalangeal I	682	78	-138

TABLE 12

COORDINATES OF SURFACE POINTS ON CLAY FORM: LARGE MALE

Line	Selected Point	X_H	Y_H	Z_H
BODY CENTERLINE	Crotch	77	0	77
		82	0	122
		79	0	144
		74	0	158
		67	0	167
		58	0	172
		56	0	187
		40	0	211
		11	0	244
		- 29	0	281
		- 57	0	303
		- 74	0	341
		- 96	0	376
		-116	0	412
		-142	0	437
		-163	0	459
		-175	0	469
		-176	0	497
		-173	0	515
	Throat	-162	0	532
		-134	0	539
	Under Chin	-115	0	547
	Front of Chin	-108	0	554
		-108	0	564
		-113	0	573
	Lip, Bottom	-108	0	586
	Mid Lip	-110	0	592
	Top Lip	-106	0	597
		-110	0	599
	Back of Nose	-110	0	614
	Tip of Nose	- 93	0	624
		- 99	0	647
	Nasion/Glabella	-111	0	670
		-110	0	681
		-110	0	701
		-119	0	725
	Top of Forehead	-129	0	744
		-142	0	758
		-178	0	774
		-206	0	778
		-238	0	775
		-278	0	757
		-299	0	731
		-301	0	731
		-310	0	701

TABLE 12
COORDINATES OF SURFACE POINT ON CLAY FORM:
LARGE MALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
Body Centerline (Continued)		-307	0	654
	Neck	-291	0	608
		-291	0	565
		-304	0	520
		-319	0	479
		-332	0	429
		-336	0	385
	Top of Seat	-341	0	374
SHOULDER TO HAND	Shoulder	-335	125	386
		-325	150	431
		-297	166	462
		-265	178	479
		-225	186	489
		-187	195	482
		-143	205	454
		-113	213	426
		- 94	217	405
		- 58	217	378
		- 60	217	379
		- 18	216	348
		8	223	321
		21	226	314
		42	231	327
		79	218	340
		137	205	362
	Wrist	185	190	385
		236	173	415
		269	153	456
		298	133	499
	Hand	306	128	504
TOP OF HEAD TO LATERAL SHOULDER	Top of Head	-207	0	778
		-202	43	767
		-201	63	749
	Front of Ear	-199	79	667
		-198	78	618
	End Line on Jaw	-197	73	580
	Start of Line on Neck	-222	66	576
		-237	63	542
	Neck and Shoulder Junction	-250	75	517
		-252	117	501
		-235	160	493
		-226	187	485
		-202	230	465

TABLE 12
COORDINATES OF SURFACE POINT ON CLAY FORM:
LARGE MALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
Top of Head to Lateral Shoulder (Continued)		-189	244	445
		-188	252	415
		-185	252	382
SIDE OF ARM TO WRIST		-185	253	382
		-128	255	345
		- 66	258	311
		- 22	261	291
	Lateral Humeral Condyle	25	266	267
	Radiale	43	267	271
		72	268	285
		122	252	315
		186	225	351
		217	211	371
	Closest to Ulnar Styloid	245	200	386
UNDERSIDE OF ARM	Scye	-241	224	328
		-186	215	308
		-147	216	291
		-107	208	264
		- 53	216	246
		- 8	216	229
	Low Pt. Elbow	29	206	221
		89	214	237
		147	196	270
		226	181	342
		257	177	370
	Wrist Crease	272	168	393
		308	166	401
		331	169	427
		348	169	448
SIDE FROM POSTERIOR SCYE TO SEAT	Posterior Scye	-240	218	326
		-196	203	267
		-174	192	237
	"Flat-Tire" Crease	-154	183	214
		-128	183	187
		-110	191	166
		- 93	198	133
	Thigh-Abdominal Junction	- 81	187	67
		- 53	209	39
		- 29	223	6
		- 10	219	- 19
	(Last Point Measured)	+ 2	218	- 27

TABLE 12
COORDINATES OF SURFACE POINT ON CLAY FORM:
LARGE MALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
OUTSIDE OF LEG		- 72	215	- 9
		+ 9	226	21
		53	226	38
		120	229	63
		217	226	96
		283	221	119
		343	215	139
		398	210	158
	Approx. 0.5 cm in front of Lateral Femoral Epicondyle	417	206	160
		442	200	133
		477	201	89
		513	203	44
	Max. Calf Circ. Point	532	201	18
		589	172	- 50
		663	137	-129
		693	131	-161
	Approx. 0.5 cm behind and below Malleolus	705	134	-175
		718	129	-189
	Lowest Points on	734	128	-222
	Leg and Foot	744	129	-220
		751	135	-214
		773	141	-190
		800	163	-159
	Metatarsal Phalangeal V	832	181	-105
		852	185	- 76
UNDERSIDE OF LEG	Base of Heel	695	88	-239
		692	89	-213
		682	95	-199
		643	102	-154
		568	120	-102
		503	133	- 60
		454	140	- 5
	Knee Pit	411	148	+ 81
		360	140	48
	(Closest Pt. to Seat)	307	132	8

TABLE 12
COORDINATES OF SURFACE POINT ON CLAY FORM:
LARGE MALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
TOEBOARD POINTS		929	227	18
		928	-227	19
		765	-226	-238
		766	227	-239
TOP OF LEG		907	131	- 15
		857	123	- 36
		823	117	- 65
		780	111	- 95
		750	110	-107
		739	108	-107
		705	113	- 95
		676	121	- 72
		645	128	- 43
		599	141	7
		573	151	52
		522	161	118
		482	164	169
	Patella	459	168	202
	Top of Knee	429	160	225
		404	157	226
		356	156	219
		249	149	188
		174	148	164
		120	144	143
		97	138	125
	Nearest to Thigh-Abdom. Jct.	54	136	108
TOE TIPS	Toe I	897	131	- 8
	Toe II	887	149	- 15
	Toe III	888	162	- 25
	Toe IV	882	173	- 37
	Toe V	874	184	- 52

TABLE 12
COORDINATES OF SURFACE POINT ON CLAY FORM:
LARGE MALE (Continued)

Line	Selected Point	X_H	Y_H	Z_H
INSIDE OF LEG	Crotch	146	9	8
		182	16	26
		226	37	47
		254	55	61
		270	64	73
		348	89	131
		404	96	168
	Closest to Med. Fem. Epicon.	452	99	135
		484	91	83
	Closest to Tibiale	511	85	45
		593	86	- 34
		624	83	- 65
		667	79	-101
		703	69	-129
	Closest to Sphyrion	722	64	-137
		753	69	-141
	Near Arch	798	77	-128
	Closest to Metatarsal Phal. I	854	90	- 68
INSIDE ARM	Anterior Scye	-115	167	421
		- 83	159	362
		- 63	157	327
		- 27	167	301
		9	183	258
	Closest to Med. Hum. Epicon.	34	191	238
		70	181	262
		100	174	287
		149	166	323
		201	154	369
	Closest to Stylion	242	141	412
	Closest to Wrist Crease	251	138	419
		262	128	431
		283	103	446

TABLE 13

ESTIMATED SEGMENT MASS AND VOLUME:
SMALL FEMALE

Segment	Predicted Volume (cm^3)	Predicted Mass (gm)
Head	3,697	3,697
Neck	601	601
Thorax	12,983	12,983 (11,944)*
Abdomen	1,610	1,610
Pelvis	6,976	6,976
Right Upper Arm	1,124	1,124
Left Upper Arm	1,124	1,124
Right Lower Arm with Hand	1,138	1,138
Left Lower Arm with Hand	1,138	1,138
Right Upper Leg	5,914	5,914
Left Upper Leg	5,914	5,914
Right Lower Leg	2,360	2,360
Left Lower Leg	2,360	2,360
Right Foot	638	638
Left Foot	638	638
TOTAL	48,215	48,215 (47,176)*

*The number in parenthesis is based on a density=0.92. This yields a total body weight less than 1 percent different from the actual value obtained by the subject population.

TABLE 14

ESTIMATED SEGMENT MASS AND VOLUME:
LARGE MALE

Segment	Predicted Volume (cm^3)	Scaled Volume (cm^3)	Estimated Mass (gm)
Head	4,753	4,511	4,511
Neck	1,231	1,168	1,168
Thorax	34,160	32,418	32,418
Abdomen	3,108	2,949	2,949
Pelvis	16,900	16,038	16,038
Right Upper Arm	2,431	2,307	2,307
Left Upper Arm	2,431	2,307	2,307
Right Lower Arm with Hand	2,556	2,426	2,426
Left Lower Arm with Hand	2,556	2,426	2,426
Right Upper Leg	11,950	11,341	11,341
Left Upper Leg	11,950	11,341	11,341
Right Lower Leg	5,331	5,059	5,059
Left Lower Leg	5,331	5,059	5,059
Right Foot	1,638	1,554	1,554
Left Foot	1,638	1,554	1,554
TOTAL	107,964	102,458	102,458*

*This mass corresponds to a weight of 225.8 lb.

TABLE 15

LOCATION OF ESTIMATED SEGMENT CENTERS OF GRAVITY WITH RESPECT TO WHOLE-BODY COORDINATE SYSTEM: SMALL FEMALE

Segment	X_H (mm)	Y_H (mm)	Z_H (mm)
Head	-184	0	578
Neck	-172	0	460
Thorax	-147	0	238
Abdomen	- 82	0	107
Pelvis	- 76	0	25
Upper Arms	- 91	±163*	280
Lower Arms with Hands	97	±176	306
Upper Legs	147	±104	- 4
Lower Legs	444	± 82	- 56
Feet	653	±101	-178

*Positive sign on Y_H refers to left side of the body.

TABLE 16

LOCATION OF ESTIMATED SEGMENT CENTERS OF GRAVITY WITH RESPECT TO WHOLE-BODY COORDINATE SYSTEM: LARGE MALE

Segment	X_H (mm)	Y_H (mm)	Z_H (mm)
Head	-205	0	678
Neck	-217	0	557
Thorax	-198	0	292
Abdomen	-118	0	120
Pelvis	- 73	0	13
Upper Arms	- 94	±205*	356
Lower Arms with Hands	183	±182	347
Upper Legs	203	±140	80
Lower Legs	514	±136	26
Feet	805	±119	-151

*Positive sign on Y_H refers to left side of body.

TABLE 17

LOCATION OF ESTIMATED SEGMENT CENTERS OF GRAVITY
WITH RESPECT TO SEGMENT COORDINATE SYSTEMS:
SMALL FEMALE

Segment	X_A (mm)	Y_A (mm)	Z_A (mm)
Head	- 2	0	33
Neck	52	0	44
Thorax	59	0	146
Abdomen	5	0	- 22
Pelvis	-76	0	20
Upper Arm (R)	115	30	-147
Upper Arm (L)	115	-30	-147
Lower Arm with Hand (R)	11	-14	-135
Lower Arm with Hand (L)	11	14	-135
Upper Leg (R)	-16	60	-143
Upper Leg (L)	-16	-60	-143
Lower Leg (R)	-13	-48	-131
Lower Leg (L)	-13	48	-131
Foot (R)	-68	3	9
Foot (L)	-68	- 3	9

TABLE 18

LOCATION OF ESTIMATED SEGMENT CENTERS OF GRAVITY
WITH RESPECT TO SEGMENT COORDINATE SYSTEMS:
LARGE MALE

Segment	X_A (mm)	Y_A (mm)	Z_A (mm)
Head	8.6	0.0	31.3
Neck	65.3	0.0	57.4
Thorax	68.3	0.0	207.5
Abdomen	- 4.7	0.0	- 24.2
Pelvis	-85.6	0.0	10.9
Upper Arm (R)	19.1	34.2	-185.6
Upper Arm (L)	19.1	-34.2	-185.6
Lower Arm with Hand (R)	-10.7	36.3	-176.5
Lower Arm with Hand (L)	-10.7	-36.3	-176.5
Upper Leg (R)	7.3	72.8	-208.6
Upper Leg (L)	7.3	-72.8	-208.6
Lower Leg (R)	-12.9	-62.7	-150.6
Lower Leg (L)	-12.9	62.7	-150.6
Foot (R)	-82.1	- 0.6	- 6.2
Foot (L)	-82.1	0.6	- 6.2

TABLE 19

ANTHROPOMETRIC VARIABLES USED IN MOMENT OF INERTIA REGRESSION EQUATIONS: SMALL FEMALE

Segment	Moment	Anthropometric Variables
Head	I_X	Stature, weight
	I_Y	Head circumference
	I_Z	Head circumference, head breadth, stature
Neck	I_X	Stature, neck circumference, neck breadth
	I_Y	Stature, neck circumference, neck length
	I_Z	Neck circumference, stature, neck length
Thorax	I_X	Weight, thorax length, bust circumference
	I_Y	Weight, thorax length, bust circumference
	I_Z	Bust circum., 10th rib breadth, thorax length
Abdomen	I_X	Stature, weight
	I_Y	Stature, weight
	I_Z	Stature, weight
Pelvis	I_X	Weight, bispinous breadth
	I_Y	Stature, weight
	I_Z	Weight, stature, suprailiac skinfold
Upper Arms	I_X	Weight, acromion-radiale length, biceps circumference (relaxed)
	I_Y	Weight, acromion-radiale length, biceps circumference (relaxed)
	I_Z	Stature, weight
Lower Arms (with hands)	I_X	Elbow circumference, forearm-hand length, wrist circumference, hand breadth
	I_Y	Elbow circumference, forearm-hand length, wrist circumference, hand breadth
	I_Z	Forearm circumference, elbow circumference, wrist circumference, forearm breadth
Upper Legs	I_X	Weight, thigh length, buttock circumference mid-thigh circumference
	I_Y	Weight, thigh length, mid-thigh circumference
	I_Z	Buttock circum., mid-thigh circum., stature
Lower Legs	I_X	Calf depth, calf length, knee circumference
	I_Y	Calf depth, calf length, knee circumference
	I_Z	Calf circum., knee circum., knee breadth
Feet	I_X	Stature, weight
	I_Y	Foot length, sphyrion height, weight, ankle circum.
	I_Z	Foot length, weight, sphyrion height, stature

TABLE 20

ANTHROPOMETRIC VARIABLES USED IN MOMENT OF INERTIA REGRESSION EQUATIONS: LARGE MALE

Segment	Moment	Anthropometric Variables
Head	I_X	Head circumference, head breadth
	I_Y	Head circumference
	I_Z	Head circumference, head length
Neck	I_X	Neck breadth, weight, neck length
	I_Y	Neck circumference, weight, neck breadth
	I_Z	Neck circumference, neck breadth, weight
Thorax	I_X	Stature, weight
	I_Y	Stature, weight
	I_Z	Weight, chest circumference (seated)
Abdomen	I_X	Waist circum., abdomen length, suprailiac skinfold
	I_Y	Circum. at R10, abdomen length, suprailiac skinfold
	I_X	Waist circum., abdomen length, suprailiac skinfold
Pelvis	I_X	Buttock circumference, suprailiac skinfold
	I_Y	Stature, weight
	I_Z	Stature, weight
Upper Arms	I_X	Weight, biceps circum., acromion-radiale length
	I_Y	Weight, triceps skinfold, axilla arm depth, biceps circum., acromion-radiale length
	I_Z	Biceps circumference, axilla arm circumference, acromion-radiale length
Forearms Plus Hands	I_X	Forearm-hand length, wrist circum., hand breadth
	I_Y	Forearm-hand length, wrist circum., hand breadth
	I_Z	Elbow circumference, mid-forearm circumference, weight, hand breadth
Upper Legs	I_X	Weight, stature, mid-thigh circum., thigh length
	I_Y	Weight, mid-thigh circum., stature, thigh length
	I_Z	Weight, mid-thigh circum., upper thigh circum.
Lower Legs	I_X	Stature, calf depth, ankle circum., calf length
	I_Y	Stature, calf depth, ankle circum., calf length
	I_Z	Calf circum., weight, calf length, calf depth
Feet	I_X	Stature, weight
	I_Y	Foot length, sphyrion height, ankle circum., weight
	I_Z	Foot length, ankle circum., sphyrion height, weight

TABLE 21

ESTIMATED SEGMENT INERTIAL PROPERTIES:
SMALL FEMALE

Segment	I_X (gm cm^2)	I_Y (gm cm^2)	I_Z (gm cm^2)
Head	146,150	172,919	131,715
Neck	6,084	9,510	10,295
Thorax	1,542,806	1,161,238	1,208,626
Abdomen	143,484	101,463	205,715
Pelvis	326,244	282,872	574,158
Upper Arms (each)	49,980	51,135	8,168
Lower Arms with Hands (each)	141,515	129,402	8,342
Upper Legs (each)	731,416	700,953	153,857
Lower Legs (each)	261,414	261,922	23,135
Feet (each)	3,441	18,428	16,614

TABLE 22

ESTIMATED SEGMENT INERTIAL PROPERTIES:
LARGE MALE

Segment	Predicted (gm cm^2)			Scaled (gm cm^2)		
	I_X	I_Y	I_Z	I_X	I_Y	I_Z
Head	229,900	267,700	171,700	225,900	263,100	168,700
Neck	22,200	24,860	32,460	21,800	24,400	31,900
Thorax	7,480,000	5,570,000	4,990,000	7,351,000	5,474,000	4,904,000
Abdomen	267,000	168,000	489,000	262,000	165,000	481,000
Pelvis	1,750,000	1,580,000	1,990,000	1,720,000	1,553,000	1,956,000
Up. Arm (L)	182,000	190,000	52,400	179,000	187,000	51,500
Up. Arm (R)	182,000	190,000	52,400	179,000	187,000	51,500
Low. Arm & Hand (L)	421,000	407,000	28,500	414,000	400,000	28,000
Low. Arm & Hand (R)	421,000	407,000	28,500	414,000	400,000	28,000
Up. Leg (L)	1,960,000	2,035,000	603,000	1,926,000	2,000,000	593,000
Up. Leg (R)	1,960,000	2,035,000	603,000	1,926,000	2,000,000	593,000
Low. Leg (L)	846,000	848,500	95,450	831,000	834,000	93,800
Low. Leg (R)	846,000	848,500	95,450	831,000	834,000	93,800
Foot (L)	10,600	76,400	79,000	10,400	75,100	77,600
Foot (R)	10,600	76,400	79,000	10,400	75,100	77,600

TABLE 23

PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES: SMALL FEMALE
(Cosine Matrix Expressed in Degrees)

Segment		X_A	Y_A	Z_A
Head	X_P	42	90	48
	Y_P	90.0	0.0	90.0
	Z_P	132	90.0	42
Neck	X_P	8.6	90.0	81.4
	Y_P	90.0	0.0	90.0
	Z_P	98.6	90.0	8.6
Thorax	X_P	19.1	90.0	70.9
	Y_P	90.0	0.0	90.0
	Z_P	109.1	90.0	19.1
Abdomen	X_P	0.0	90.0	90.0
	Y_P	90.0	0.0	90.0
	Z_P	90.0	90.0	0.0
Pelvis	X_P	2.7	90.0	92.7
	Y_P	90.0	0.0	90.0
	Z_P	87.3	90.0	2.7
Upper Arm (L)	X_P	27	116.6	84.1
	Y_P	63.4	27.7	97.3
	Z_P	92.5	82.9	8.6
Upper Arm (R)	X_P	27	63.4	84.1
	Y_P	116.6	27.7	82.9
	Z_P	92.5	97.3	8.6
Lower Arm with Hand (L)	X_P	17	74.4	95.4
	Y_P	105.6	17.3	82.8
	Z_P	82.6	97.2	9.7
Lower Arm with Hand (R)	X_P	17	105.6	95.4
	Y_P	74.4	17.3	97.2
	Z_P	82.6	82.8	9.7
Upper Leg (L)	X_P	15.2	77.3	81.7
	Y_P	102.7	12.8	88.8
	Z_P	98.3	91.2	8.4
Upper Leg (R)	X_P	15.2	102.7	81.7
	Y_P	77.3	12.8	91.2
	Z_P	98.3	88.8	8.4

TABLE 23
PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES:
SMALL FEMALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_A	Y_A	Z_A
Lower Leg (L)	X_P	0.0	90.0	90.0
	Y_P	90.0	0.0	90.0
	Z_P	90.0	90.0	0.0
Lower Leg (R)	X_P	0.0	90.0	90.0
	Y_P	90.0	0.0	90.0
	Z_P	90.0	90.0	0.0
Foot (L)	X_P	6.3	90.3	96.3
	Y_P	91.5	16.5	106.4
	Z_P	83.7	73.5	17.6
Foot (R)	X_P	6.3	89.7	96.3
	Y_P	88.4	16.5	73.6
	Z_P	83.7	106.5	17.6

TABLE 24

PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES: LARGE MALE
(Cosine Matrix Expressed in Degrees)

Segment		X_A	Y_A	Z_A
Head	X_P	36	90	54
	Y_P	90.0	0.0	90.0
	Z_P	126	90.0	36
Neck	X_P	11	90.0	79
	Y_P	90.0	0.0	90.0
	Z_P	101	90.0	11
Thorax	X_P	14.5	90.0	75.5
	Y_P	90.0	0.0	90.0
	Z_P	104.5	90.0	14.5
Abdomen	X_P	2.6	90.0	92.2
	Y_P	90.0	0.0	90.0
	Z_P	87.8	90.0	2.6
Pelvis	X_P	8.4	90.0	81.6
	Y_P	90.0	0.0	90.0
	Z_P	98.4	90.0	8.4
Upper Arm (L)	X_P	33.9	56.1	90.0
	Y_P	123.9	33.9	90.0
	Z_P	90.0	90.0	0.0
Upper Arm (R)	X_P	33.9	123.9	90.0
	Y_P	56.1	33.9	90.0
	Z_P	90.0	90.0	0.0
Lower Arm with Hand (L)	X_P	19.5	70.5	90.0
	Y_P	109.5	19.5	90.0
	Z_P	90.0	90.0	1
Lower Arm with Hand (R)	X_P	19.5	109.5	90.0
	Y_P	70.5	19.5	90.0
	Z_P	90.0	90.0	1
Upper Leg (L)	X_P	9.8	80.2	90.0
	Y_P	99.8	9.8	90.0
	Z_P	90.0	90.0	0.0
Upper Leg (R)	X_P	9.8	99.8	90.0
	Y_P	80.2	9.8	90.0
	Z_P	90.0	90.0	0.0

TABLE 24
PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES:
LARGE MALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_A	Y_A	Z_A
Calf (L)	X_P	24	114	90
	Y_P	66	24	92
	Z_P	90	88	1
Calf (R)	X_P	24	66	90
	Y_P	114	24	88
	Z_P	90	92	1
Foot (L)	X_P	10	94	81
	Y_P	86	7	95
	Z_P	99	85	10
Foot (R)	X_P	10	86	81
	Y_P	94	7	85
	Z_P	99	95	10

TABLE 25

PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES: SMALL FEMALE
(Cosine Matrix)

Segment		X_A	Y_A	Z_A
Head	X_P	0.743	0.000	0.669
	Y_P	0.000	1.000	0.000
	Z_P	-0.669	0.000	0.743
Neck	X_P	0.989	0.000	0.150
	Y_P	0.000	1.000	0.000
	Z_P	-0.150	0.000	0.989
Thorax	X_P	0.945	0.000	0.327
	Y_P	0.000	1.000	0.000
	Z_P	-0.327	0.000	0.945
Abdomen	X_P	1.000	0.000	0.000
	Y_P	0.000	1.000	0.000
	Z_P	0.000	0.000	1.000
Pelvis	X_P	0.999	0.000	-0.047
	Y_P	0.000	1.000	0.000
	Z_P	0.047	0.000	0.999
Upper Arm (L)	X_P	0.891	-0.448	0.103
	Y_P	0.448	0.885	-0.127
	Z_P	-0.044	0.124	0.989
Upper Arm (R)	X_P	0.891	0.448	0.103
	Y_P	-0.448	0.885	0.124
	Z_P	-0.044	-0.127	0.989
Lower Arm with Hand (L)	X_P	0.956	0.269	-0.094
	Y_P	-0.269	0.955	0.125
	Z_P	0.129	-0.125	0.986
Lower Arm with Hand (R)	X_P	0.956	-0.269	-0.094
	Y_P	0.269	0.955	-0.125
	Z_P	0.129	0.125	0.986
Upper Leg (L)	X_P	0.965	0.220	0.144
	Y_P	-0.220	0.975	0.021
	Z_P	-0.144	-0.021	0.989
Upper Leg (R)	X_P	0.965	-0.220	0.144
	Y_P	0.220	0.975	-0.021
	Z_P	-0.144	0.021	0.989

TABLE 25
PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES:
SMALL FEMALE (Cosine Matrix, Continued)

Segment		X_A	Y_A	Z_A
Lower Leg (L)	X_P	1.000	0.000	0.000
	Y_P	0.000	1.000	0.000
	Z_P	0.000	0.000	1.000
Lower Leg (R)	X_P	1.000	0.000	0.000
	Y_P	0.000	1.000	0.000
	Z_P	0.000	0.000	1.000
Foot (L)	X_P	0.994	-0.005	-0.110
	Y_P	-0.027	0.959	-0.282
	Z_P	0.110	0.284	0.953
Foot (R)	X_P	0.994	0.005	-0.110
	Y_P	0.027	0.959	0.282
	Z_P	0.110	-0.284	0.953

TABLE 26

PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES: LARGE MALE
(Cosine Matrix)

Segment		X_A	Y_A	Z_A
Head	X_P	.809	0.000	0.588
	Y_P	.000	1.000	0.000
	Z_P	-.588	0.000	0.809
Neck	X_P	.981	0.000	0.192
	Y_P	.000	1.000	0.000
	Z_P	-.192	0.000	0.981
Thorax	X_P	.968	0.000	0.250
	Y_P	.000	1.000	0.000
	Z_P	-.250	0.000	0.968
Abdomen	X_P	.999	0.000	-0.038
	Y_P	.000	1.000	0.000
	Z_P	.038	0.000	0.999
Pelvis	X_P	.989	0.000	0.146
	Y_P	.000	1.000	0.000
	Z_P	-.146	0.000	0.989
Upper Arm (L)	X_P	.830	0.558	0.000
	Y_P	-.558	0.830	0.000
	Z_P	.000	0.000	1.000
Upper Arm (R)	X_P	.830	-0.558	0.000
	Y_P	-.558	0.830	0.000
	Z_P	.000	0.000	1.000
Lower Arm with Hand (L)	X_P	.943	0.334	0.000
	Y_P	-.334	0.943	0.000
	Z_P	.000	0.000	1.000
Lower Arm with Hand (R)	X_P	.943	-0.334	0.000
	Y_P	.334	0.943	0.000
	Z_P	.000	0.000	1.000
Upper Leg (L)	X_P	.985	0.170	0.000
	Y_P	-.170	0.985	0.000
	Z_P	.000	0.000	1.000
Upper Leg (R)	X_P	.985	-0.170	0.000
	Y_P	.170	0.985	0.000
	Z_P	.000	0.000	1.000

TABLE 26
PRINCIPAL AXES OF INERTIA WITH RESPECT TO ANATOMICAL AXES:
LARGE MALE (Cosine Matrix, Continued)

Segment		X_A	Y_A	Z_A
Calf (L)	X_P	.913	-0.407	0.000
	Y_P	.407	0.913	-0.0349
	Z_P	.000	0.0349	1.000
Calf (R)	X_P	.913	0.407	0.000
	Y_P	-.407	0.913	0.0349
	Z_P	.000	-0.0349	1.000
Foot (L)	X_P	.985	-0.0698	0.156
	Y_P	.0698	0.992	-0.0872
	Z_P	-.156	0.0872	0.985
Foot (R)	X_P	.985	0.0698	0.156
	Y_P	-.0698	0.992	0.0872
	Z_P	-.156	-0.0872	0.985

TABLE 27

PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM: SMALL FEMALE
(Cosine Matrix Expressed in Degrees)

Segment		X_H	Y_H	Z_H
Head	X_P	45.7	90.0	44.3
	Y_P	90.0	0.0	90.0
	Z_P	135.7	90.0	45.7
Neck	X_P	18.7	90.0	109.0
	Y_P	90.0	0.0	90.0
	Z_P	71.0	90.0	18.7
Thorax	X_P	28	90.0	62
	Y_P	90.0	0.0	90.0
	Z_P	118	90.0	28
Abdomen	X_P	24.7	90.0	65.3
	Y_P	90.0	0.0	90.0
	Z_P	114.7	90.0	24.7
Pelvis	X_P	51.2	90.0	38.7
	Y_P	90.0	0.0	90.0
	Z_P	141.3	90.0	51.2
Upper Arm (L)	X_P	61	127	50
	Y_P	68	36	63
	Z_P	143	91	53
Upper Arm (R)	X_P	61	53	50
	Y_P	112	36	117
	Z_P	143	89	53
Lower Arm with Hand (L)	X_P	134.7	63.3	57
	Y_P	66.6	27.6	103.9
	Z_P	127.1	88.9	143.1
Lower Arm with Hand (R)	X_P	134.7	116.7	57
	Y_P	113.3	27.6	76.1
	Z_P	127.1	91.1	143.1
Upper Leg (L)	X_P	110.6	78.6	23.8
	Y_P	77.8	14.3	97.0
	Z_P	154.6	79.6	112.8
Upper Leg (R)	X_P	110.6	101.4	23.8
	Y_P	102.2	14.3	83.0
	Z_P	154.6	100.4	112.8

TABLE 27
PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM:
SMALL FEMALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_P	50.4	65.7	49.3
	Y_P	109.9	24.7	103.9
	Z_P	133.7	93.9	44
Lower Leg (R)	X_P	50.4	114.3	49.3
	Y_P	70.1	24.7	76.1
	Z_P	133.7	86.1	44
Foot (L)	X_P	53.6	66.4	45.4
	Y_P	96.8	25.4	114.5
	Z_P	142.8	80.6	54.5
Foot (R)	X_P	53.6	113.6	45.4
	Y_P	83.2	25.4	65.5
	Z_P	142.8	99.4	54.5

TABLE 28

PRINCIPAL AXES OF INERTIA WITH RESPECT TO
HIP POINT AXIS SYSTEM: LARGE MALE
(Cosine Matrix Expressed in Degrees)

Segment		X_H	Y_H	Z_H
Head	X_P	38.7	90.0	51.3
	Y_P	90.0	0.0	90.0
	Z_P	128.7	90.0	38.7
Neck	X_P	13.2	90.0	103.1
	Y_P	90.0	0.0	90.0
	Z_P	76.9	90.0	13.2
Thorax	X_P	22.3	90.0	67.6
	Y_P	90.0	0.0	90.0
	Z_P	112.4	90.0	22.3
Abdomen	X_P	28.5	90.0	61.5
	Y_P	90.0	0.0	90.0
	Z_P	118.5	90.0	28.5
Pelvis	X_P	73.3	90.0	16.7
	Y_P	90.0	0.0	90.0
	Z_P	163.3	90.0	73.3
Upper Arm (L)	X_P	59.9	78.8	32.6
	Y_P	102.8	13.9	95.2
	Z_P	146.7	98.1	58.0
Upper Arm (R)	X_P	59.9	101.2	32.6
	Y_P	77.2	13.9	84.8
	Z_P	146.7	81.9	58.0
Lower Arm with Hand (L)	X_P	107.5	50.6	44.6
	Y_P	58.3	42.8	115.6
	Z_P	142.8	75.9	123.6
Lower Arm with Hand (R)	X_P	107.5	129.4	44.6
	Y_P	121.7	42.8	64.4
	Z_P	142.8	104.1	123.6
Upper Leg (L)	X_P	113.2	72.3	29.8
	Y_P	81.8	17.9	105.6
	Z_P	155.2	88.9	114.7
Upper Leg (R)	X_P	113.2	107.7	29.8
	Y_P	98.2	17.9	74.4
	Z_P	155.2	91.1	114.7

TABLE 28
PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM:
LARGE MALE (Cosine Matrix Expressed in Degrees, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_P	44.4	89.4	45.7
	Y_P	85.8	6.5	95.3
	Z_P	134.9	83.5	45.6
Lower Leg (R)	X_P	44.4	90.6	45.7
	Y_P	94.2	6.5	84.7
	Z_P	134.9	96.5	45.6
Foot (L)	X_P	66.7	82.5	24.6
	Y_P	85.9	12.0	100.8
	Z_P	156.9	82.7	68.0
Foot (R)	X_P	66.7	97.5	24.6
	Y_P	94.1	12.0	79.2
	Z_P	156.9	97.3	68.0

TABLE 29

PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM: SMALL FEMALE
(Cosine Matrix)

Segment		X_H	Y_H	Z_H
Head	X_P	.968	0.000	.716
	Y_P	.000	1.000	.000
	Z_P	-.716	0.000	.698
Neck	X_P	.947	0.000	-.325
	Y_P	.000	1.000	.000
	Z_P	.325	0.000	.947
Thorax	X_P	.885	0.000	.466
	Y_P	.000	1.000	.000
	Z_P	-.466	0.000	.885
Abdomen	X_P	.909	0.000	.418
	Y_P	.000	1.000	.000
	Z_P	-.418	0.000	.909
Pelvis	X_P	.626	0.000	.780
	Y_P	.000	1.000	.000
	Z_P	-.780	0.000	.626
Upper Arm (L)	X_P	.48	-0.60	.64
	Y_P	.37	0.81	.46
	Z_P	-.80	-0.01	.60
Upper Arm (R)	X_P	.48	0.60	.64
	Y_P	-.37	0.81	-.46
	Z_P	-.80	0.01	.60
Lower Arm with Hand (L)	X_P	-.704	0.449	.545
	Y_P	.397	0.886	-.240
	Z_P	-.603	0.019	-.800
Lower Arm with Hand (R)	X_P	-.704	-0.449	.545
	Y_P	-.397	0.886	.240
	Z_P	-.603	-0.019	-.800
Upper Leg (L)	X_P	-.352	0.197	.915
	Y_P	.212	0.969	-.122
	Z_P	-.903	0.181	-.388
Upper Leg (R)	X_P	-.352	-0.197	.915
	Y_P	-.212	0.969	.122
	Z_P	-.903	-0.181	-.388

TABLE 29
PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM:
SMALL FEMALE (Cosine Matrix, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_P	.637	0.412	.652
	Y_P	-.341	0.909	-.241
	Z_P	-.691	-0.069	.719
Lower Leg (R)	X_P	.637	-0.412	.652
	Y_P	.341	0.909	.241
	Z_P	-.691	0.069	.719
Foot (L)	X_P	.593	0.400	.702
	Y_P	-.119	0.903	-.415
	Z_P	-.797	0.163	.581
Foot (R)	X_P	.593	-0.400	.702
	Y_P	.119	0.903	.415
	Z_P	-.797	-0.163	.581

TABLE 30

PRINCIPAL AXES OF INERTIA WITH RESPECT TO
HIP POINT AXIS SYSTEM: LARGE MALE
(Cosine Matrix)

Segment		X_H	Y_H	Z_H
Head	X_P	.780	0.000	.626
	Y_P	.000	1.000	.000
	Z_P	-.626	0.000	.780
Neck	X_P	.973	0.000	-.227
	Y_P	.000	1.000	.000
	Z_P	.227	0.000	.973
Thorax	X_P	.925	0.000	.380
	Y_P	.000	1.000	.000
	Z_P	-.380	0.000	.925
Abdomen	X_P	.879	0.000	.478
	Y_P	.000	1.000	.000
	Z_P	-.478	0.000	.879
Pelvis	X_P	.287	0.000	.958
	Y_P	.000	1.000	.000
	Z_P	-.958	0.000	.287
Upper Arm (L)	X_P	.502	0.195	.842
	Y_P	-.222	0.971	-.091
	Z_P	-.836	-0.141	.530
Upper Arm (R)	X_P	.502	-0.195	.842
	Y_P	.222	0.971	.091
	Z_P	-.836	0.141	.530
Lower Arm with Hand (L)	X_P	-.301	0.634	.712
	Y_P	.525	0.734	-.433
	Z_P	-.797	0.243	-.554
Lower Arm with Hand (R)	X_P	-.301	-0.634	.712
	Y_P	-.525	0.734	.433
	Z_P	-.797	-0.243	-.554
Upper Leg (L)	X_P	-.393	0.303	.868
	Y_P	.143	0.952	-.268
	Z_P	-.908	0.019	-.418
Upper Leg (R)	X_P	-.393	-0.303	.868
	Y_P	-.143	0.952	.268
	Z_P	-.908	-0.019	-.418

TABLE 30
PRINCIPAL AXES OF INERTIA WITH RESPECT TO HIP POINT AXIS SYSTEM:
LARGE MALE (Cosine Matrix, Continued)

Segment		X_H	Y_H	Z_H
Lower Leg (L)	X_P	.715	0.011	.699
	Y_P	.074	0.994	-.092
	Z_P	-.706	0.114	.700
Lower Leg (R)	X_P	.715	-0.011	.699
	Y_P	-.074	0.994	.092
	Z_P	-.706	-0.114	.700
Foot (L)	X_P	.395	0.130	.909
	Y_P	.071	0.978	-.187
	Z_P	-.920	0.128	.375
Foot (R)	X_P	.395	-0.130	.909
	Y_P	-.071	0.978	.187
	Z_P	-.920	-0.128	.375

TABLE 31

LOCATION OF JOINT CENTERS: SMALL FEMALE

Joint	X_H (mm)	Y_H (mm)	Z_H (mm)
Head/Neck	-189	0	519
C7/T1	-183	0	429
T4/T5	-205	0	381
T8/T9	-196	0	273
T12/L1	-149	0	140
L2/L3	-121	0	102
L5/S1	- 80	0	46
Sternoclavicular	-146	± 17	389
Claviscapular	-211	±140	390
Glenohumeral	-174	±146	354
Elbow	20	±179	188
Wrist	134	±155	385
Hip	0	± 80	0
Knee	363	± 75	71
Ankle	593	± 86	-182

TABLE 32

LOCATION OF JOINT CENTERS: LARGE MALE

Joint	X_H (mm)	Y_H (mm)	Z_H (mm)
Head/Neck	-222	0	619
C7/T1	-216	0	506
T4/T5	-248	0	439
T8/T9	-246	0	320
T12/L1	-203	0	175
L2/L3	-159	0	122
L5/S1	- 93	0	42
Sternoclavicular	-171	± 25	462
Claviscapular	-261	±177	470
Glenohumeral	-217	±186	427
Elbow	36	±225	242
Wrist	264	±162	406
Hip	0	± 86	0
Knee	413	±153	166
Ankle	718	± 99	-152

TABLE 33

LOCATION OF JOINT CENTERS IN SEGMENT COORDINATES:
SMALL FEMALE

Joint	Segment	Coordinates (mm)		
		X_A	Y_A	Z_A
Head/Neck	Head	- 11	0	- 25
Head/Neck	Neck	9	0	88
C7/T1	Neck	56	0	11
C7/T1	Thorax	52	0	340
T4/T5	Thorax	23	0	296
T8/T9	Thorax	16	0	188
T12/L1	Thorax	42	0	49
L2/L3	Thorax	64	0	7
L2/L3	Abdomen	- 32	0	- 10
L5/S1	Abdomen	- 18	0	- 78
L5/S1	Pelvis	- 62	0	35
Sternoclavicular (L)	Thorax	82	17	295
Sternoclavicular (R)	Thorax	82	- 17	295
Claviscapular (L)	Thorax	18	140	306
Claviscapular (R)	Thorax	18	-140	306
Glenohumeral (L)	Thorax	50	146	265
Glenohumeral (R)	Thorax	50	-146	265
Glenohumeral (L)	Upper Arm (L)	7	- 29	- 35
Glenohumeral (R)	Upper Arm (R)	7	29	- 35
Elbow (L)	Upper Arm (L)	- 3	- 35	-292
Elbow (R)	Upper Arm (R)	- 3	35	-292
Elbow (L)	Lower Arm (L)	- 1	- 29	5
Elbow (R)	Lower Arm (R)	- 1	29	5
Wrist (L)	Lower Arm (L)	- 8	- 25	-224
Wrist (R)	Lower Arm (R)	- 8	25	-224
Hip (L)	Pelvis	- 52	80	- 56
Hip (R)	Pelvis	- 52	- 80	- 56
Hip (L)	Upper Leg (L)	27	-109	- 9
Hip (R)	Upper Leg (R)	27	109	- 9
Knee (L)	Upper Leg (L)	0	- 42	-372
Knee (R)	Upper Leg (R)	0	42	-372
Knee (L)	Lower Leg (L)	15	38	17
Knee (R)	Lower Leg (R)	15	- 38	17
Ankle (L)	Lower Leg (L)	1	31	-325
Ankle (R)	Lower Leg (R)	1	- 31	-325
Ankle (L)	Foot (L)	-104	- 12	58
Ankle (R)	Foot (R)	-104	12	58

TABLE 34

LOCATION OF JOINT CENTERS IN SEGMENT COORDINATES:
LARGE MALE

Joint	Segment	Coordinates (mm)		
		X_A	Y_A	Z_A
Head/Neck	Head	- 11	0	- 26
Head/Neck	Neck	35	0	112
C7/T1	Neck	87	0	12
C7/T1	Thorax	80	0	422
T4/T5	Thorax	39	0	360
T8/T9	Thorax	24	0	242
T12/L1	Thorax	47	0	92
L2/L3	Thorax	83	0	34
L2/L3	Abdomen	- 39	0	- 1
L5/S1	Abdomen	- 23	0	-104
L5/S1	Pelvis	- 68	0	41
Sternoclavicular (L)	Thorax	118	25	372
Sternoclavicular (R)	Thorax	118	- 25	372
Clávicscapular (L)	Thorax	78	177	386
Claviscapular (R)	Thorax	78	-177	386
Glenohumeral (L)	Thorax	68	186	348
Glenohumeral (R)	Thorax	68	-186	348
Glenohumeral (L)	Upper Arm (L)	13	- 35	- 43
Glenohumeral (R)	Upper Arm (R)	13	35	- 43
Elbow (L)	Upper Arm (L)	- 4	- 48	-358
Elbow (R)	Upper Arm (R)	- 4	48	-358
Elbow (L)	Lower Arm (L)	- 14	- 37	10
Elbow (R)	Lower Arm (R)	- 14	37	10
Wrist (L)	Lower Arm (L)	- 7	- 32	-278
Wrist (R)	Lower Arm (R)	- 7	32	-278
Hip (L)	Pelvis	- 66	86	- 61
Hip (R)	Pelvis	- 66	- 86	- 61
Hip (L)	Upper Leg (L)	11	-132	8
Hip (R)	Upper Leg (R)	11	132	8
Knee (L)	Upper Leg (L)	0	- 54	-435
Knee (R)	Upper Leg (R)	0	54	-435
Knee (L)	Lower Leg (L)	12	55	21
Knee (R)	Lower Leg (R)	12	- 55	21
Ankle (L)	Lower Leg (L)	0	41	-423
Ankle (R)	Lower Leg (R)	0	- 41	-423
Ankle (L)	Foot (L)	-133	- 15	65
Ankle (R)	Foot (R)	-133	15	65

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