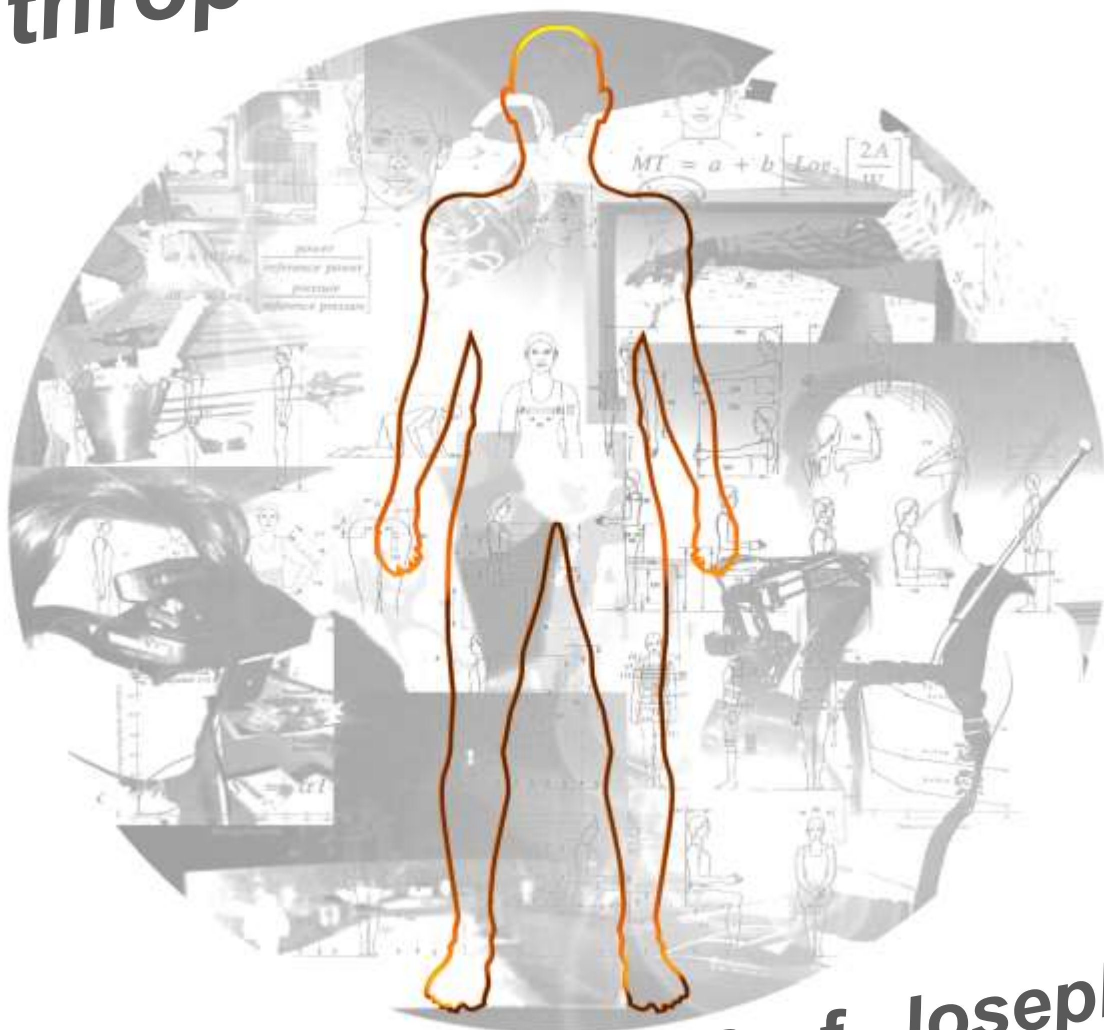
Anthropometry



Prof. Joseph Giacomin

Adolpe Quetelet

Received his doctorate in 1819 from Ghent University for a dissertation on the theory of conic sections.

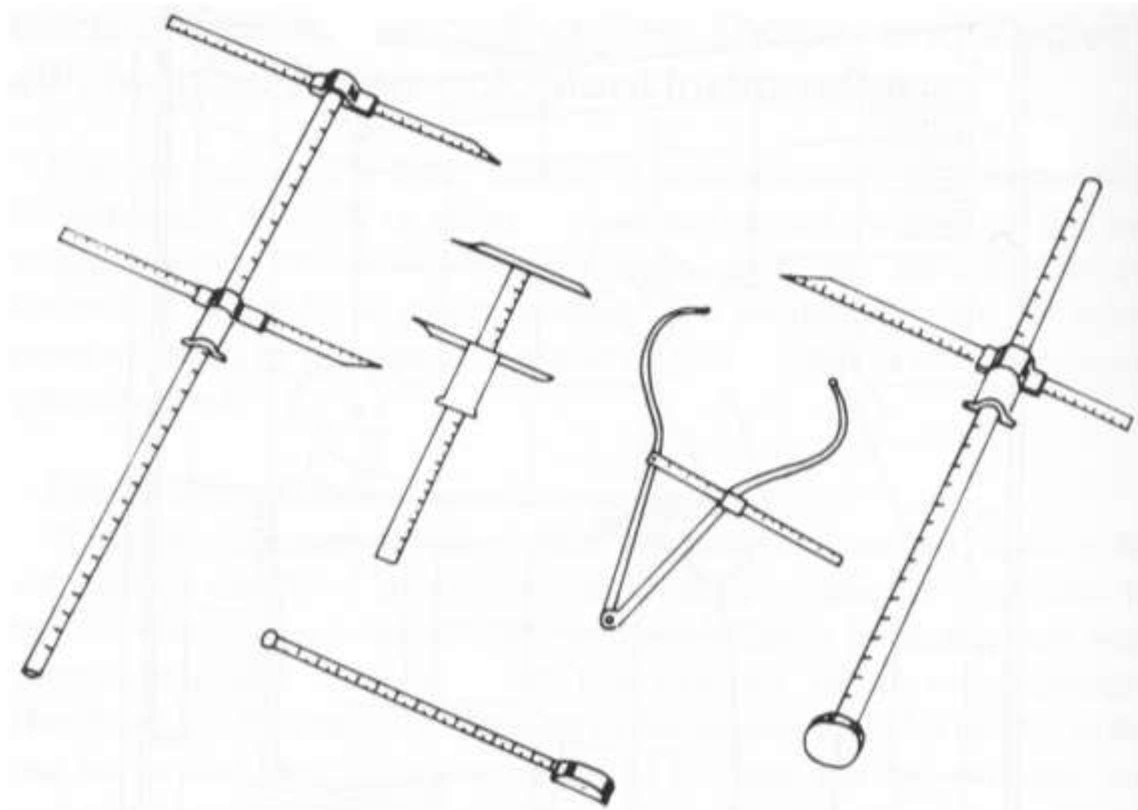
In 1823 in Paris studied astronomy under Arago and Bouvard, and the theory of probability under Fourier and Laplace. Influenced by them, he was the first person to use the normal curve for purposes other than modelling error.

His statistical analysis of crime data caused debate about the role of free will versus social determinism.

In *Sur l'homme et le developpement de ses facultés, essai d'une physique sociale* (1835) he presented his theory of the average man about which measurements of a human trait are grouped according to the normal curve.

In 1844 Adolpe Quetelet published a statistical analysis of the chest sizes of 5000 Scottish soldiers. This was the birth of the science of anthropometry.

In 1853 he organised the first international statistics conference and later devised the *Quetelet index (also called body mass index)* which is used to measure obesity.



Anthropometry

The science involving the quantitative measurement of the human body.

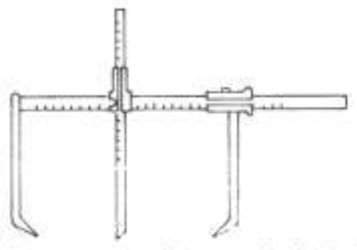
First applied to the bone structures of early man, then later to the study of the races and ethnic groups of modern man.

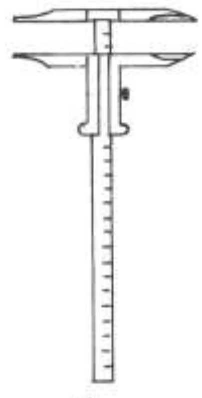
Developments accelerated during WWII due to need to design better aircraft cockpits.

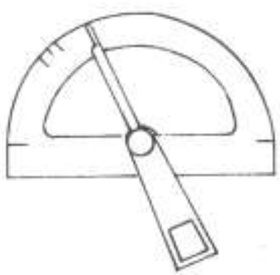
It has become a basic tool of most product development programmes.

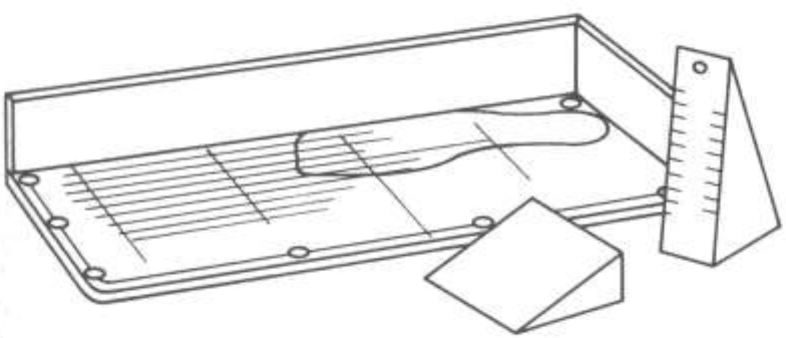
Anthropometric Measurement Tools

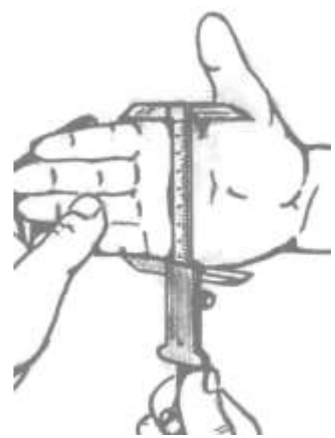
A variety of simple callipers and goniometers are available for performing simple anthropometric measurements.

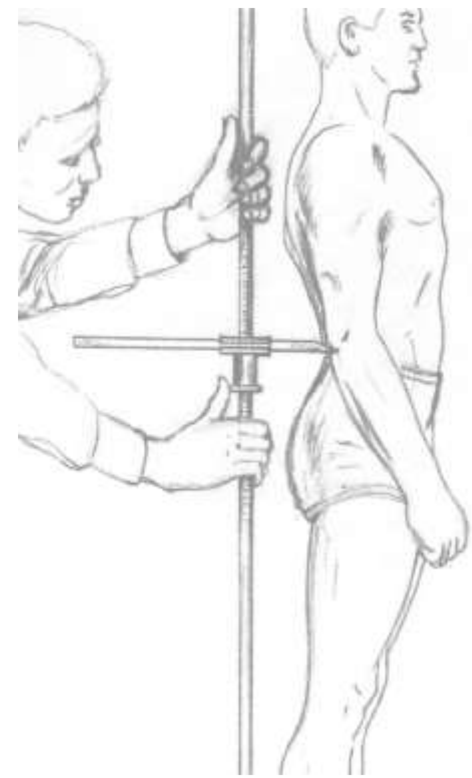












Anthropometric Measurements

Height: a straight line point-to-point vertical measurement

Breadth: a straight line point-to-point horizontal measurement across the body segment

Depth: a straight line, point-to-point horizontal measurement running for-aft along the body

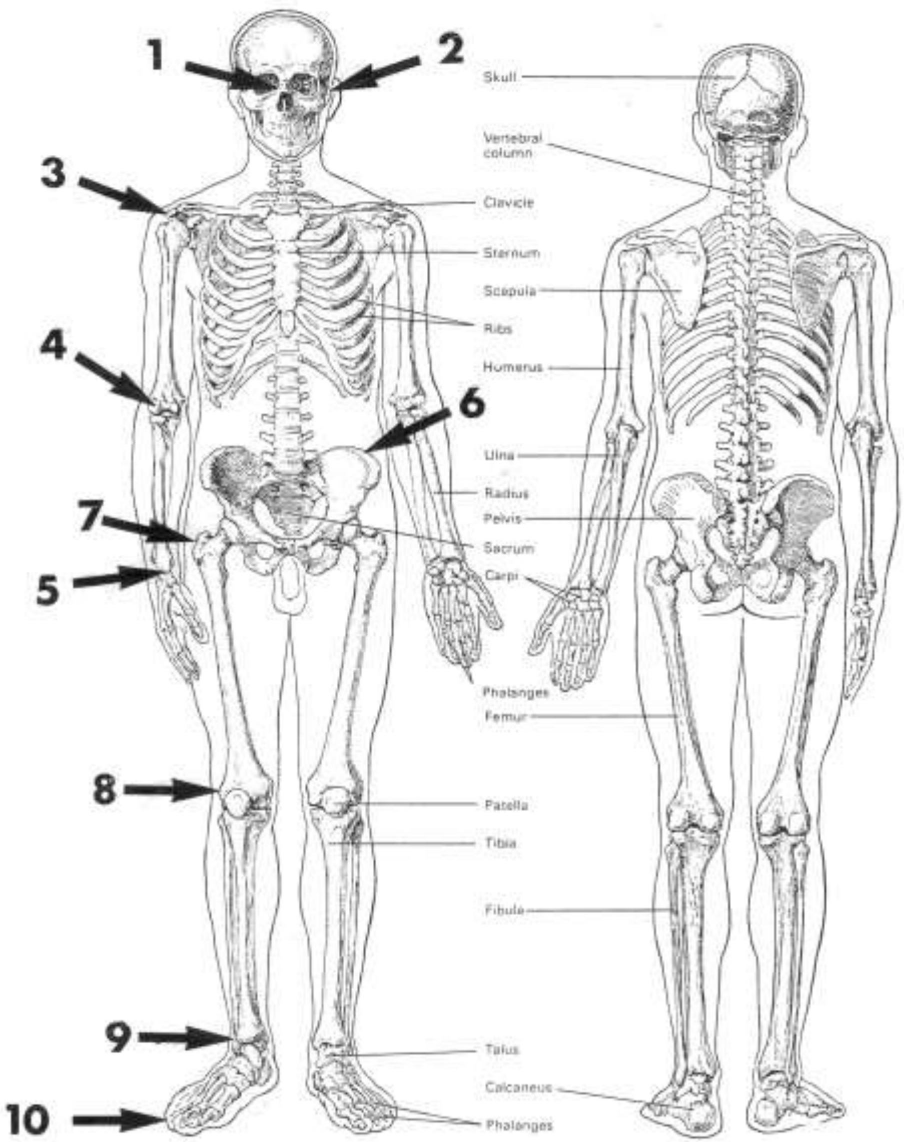
Distance: a straight line, point-to-point measurement between body landma**rks**

Curvature: a point-to-point measurement along a contour which is neither closed nor circular

Circumference: a closed measurement that follows a contour which is not circular

Reach: a point-to-point measurement following the long axis of the arm or leg

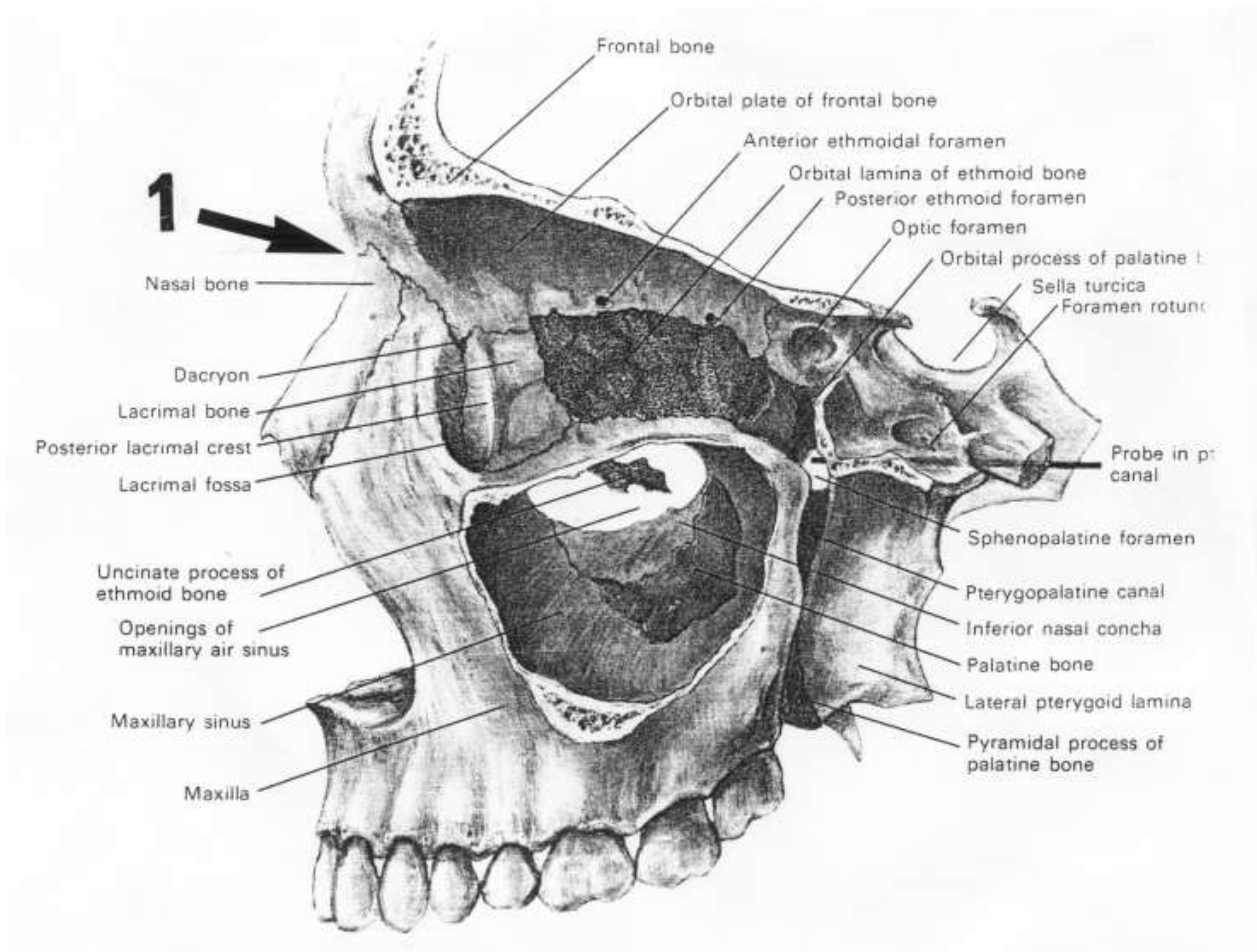
Anthropometric Measurement Example



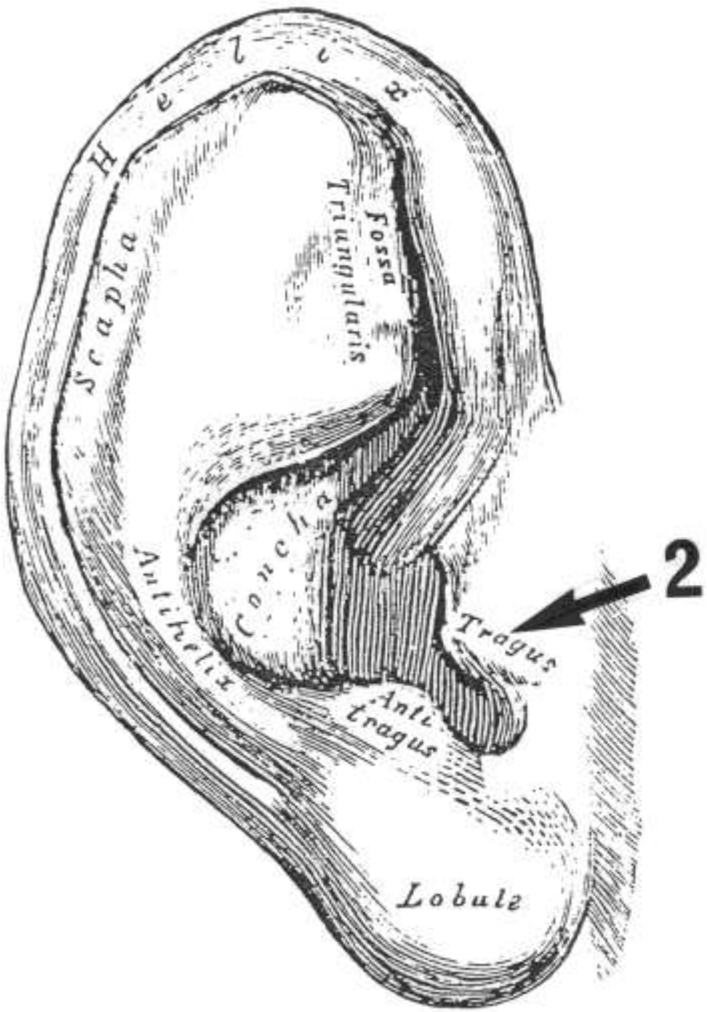
1 – nasal bone
2 – tragus
3 – acromion
4 – external elbow epicondyle
5 – styloid process
6 – highest point of illiac crest
7 – greater trochanter
8 – external femoral epicondyle
9 – external malleolus
10 – head of fifth metatarsal

Anthropometric Measurement Example

1 – nasal bone

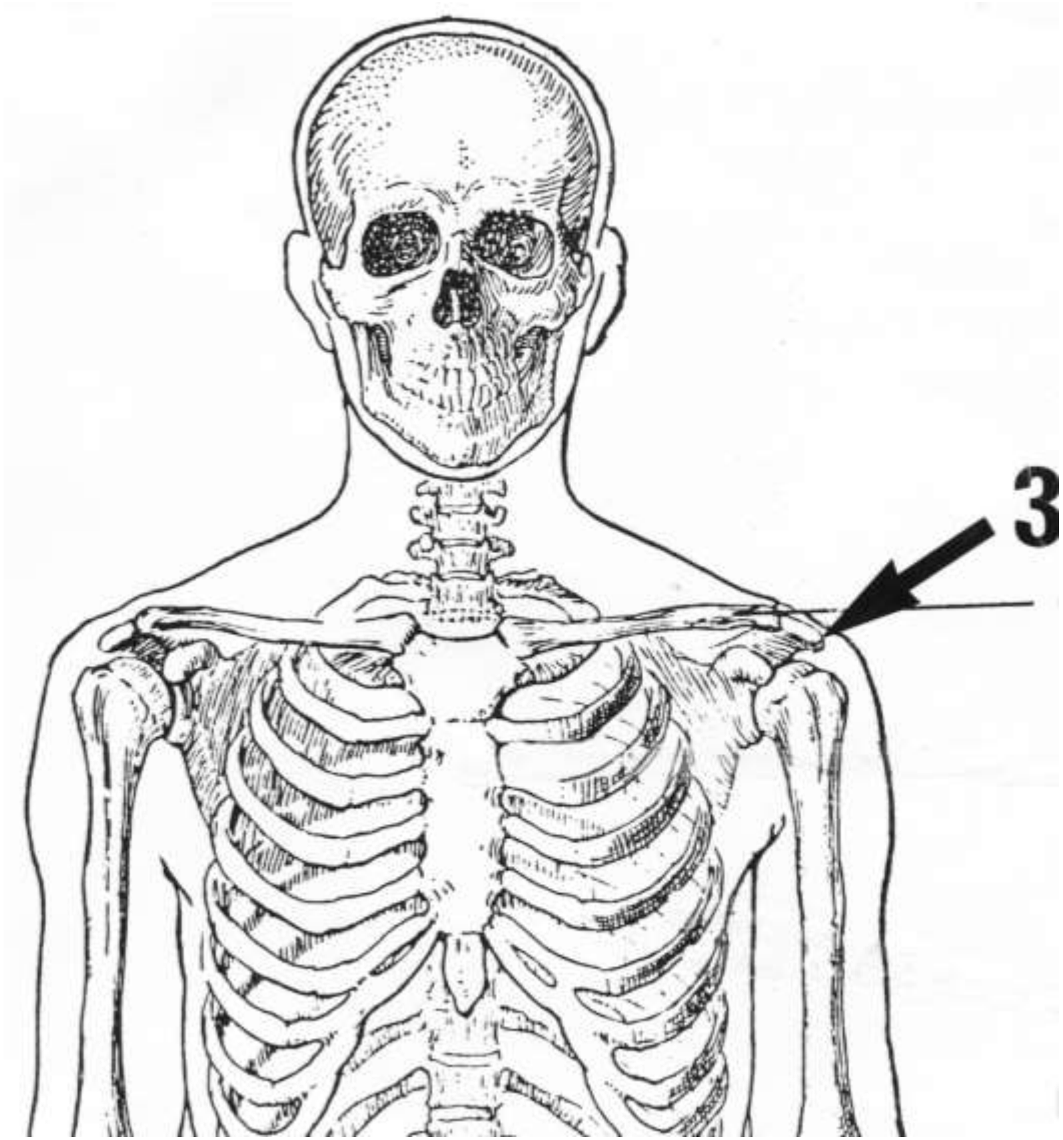


Anthropometric Measurement Example

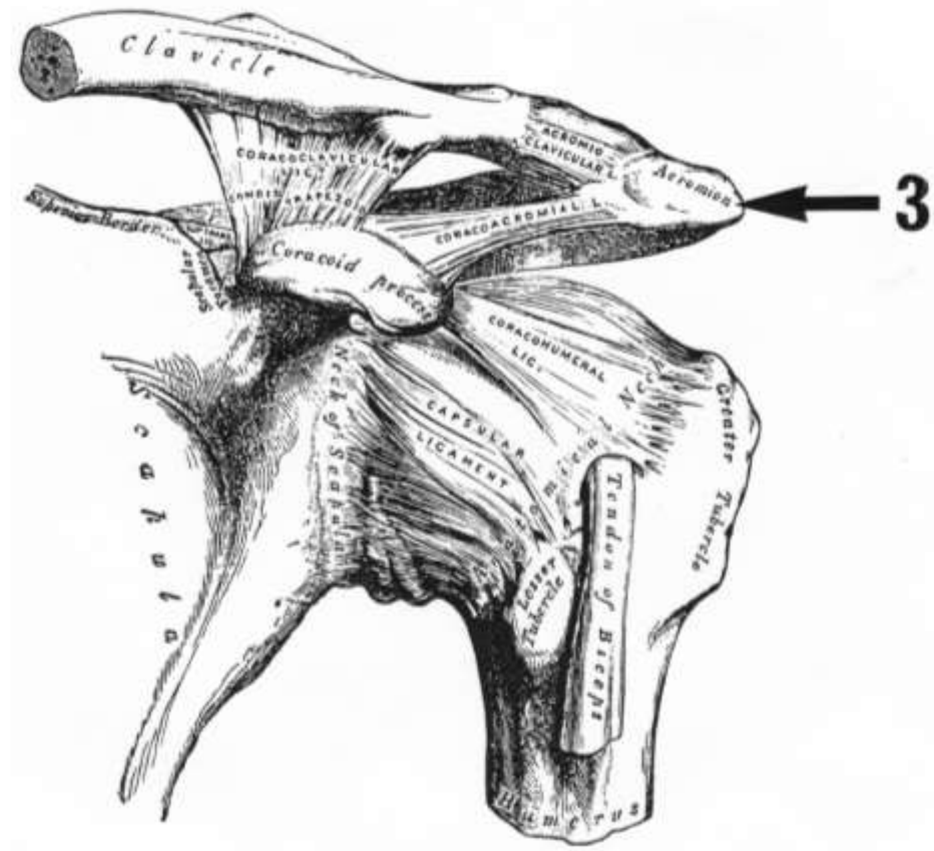


2 – tragus

Anthropometric Measurement Example

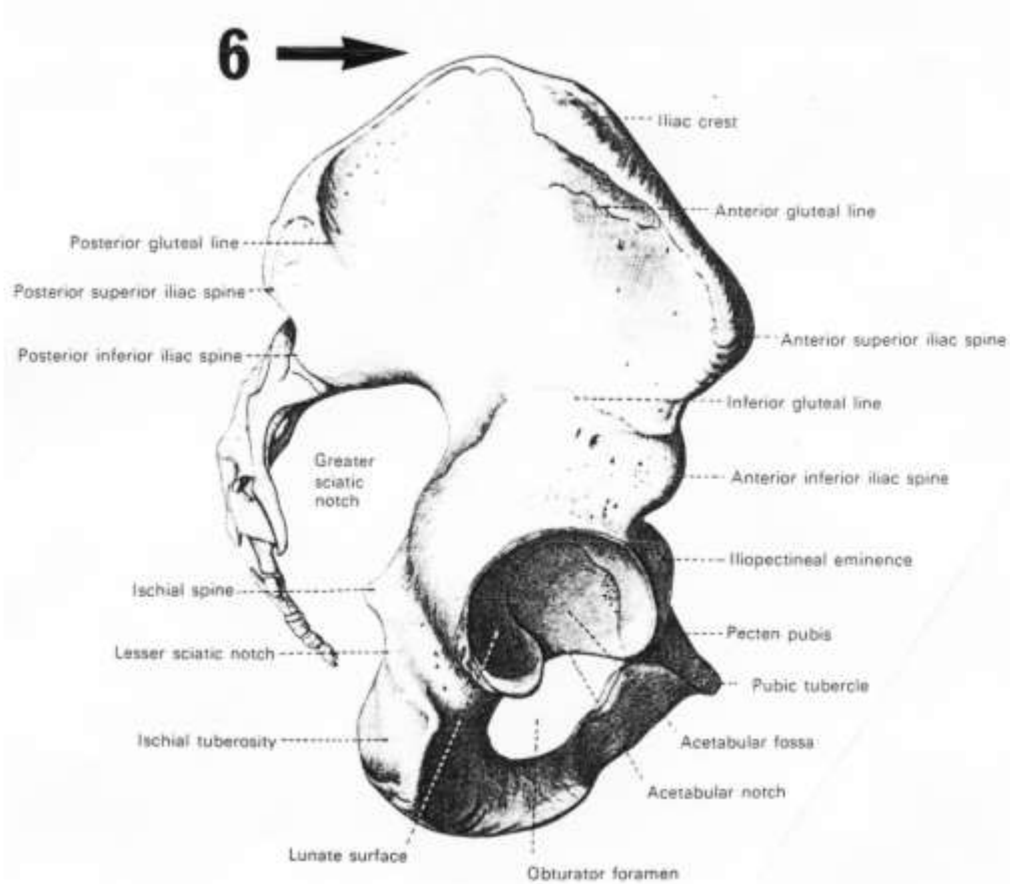


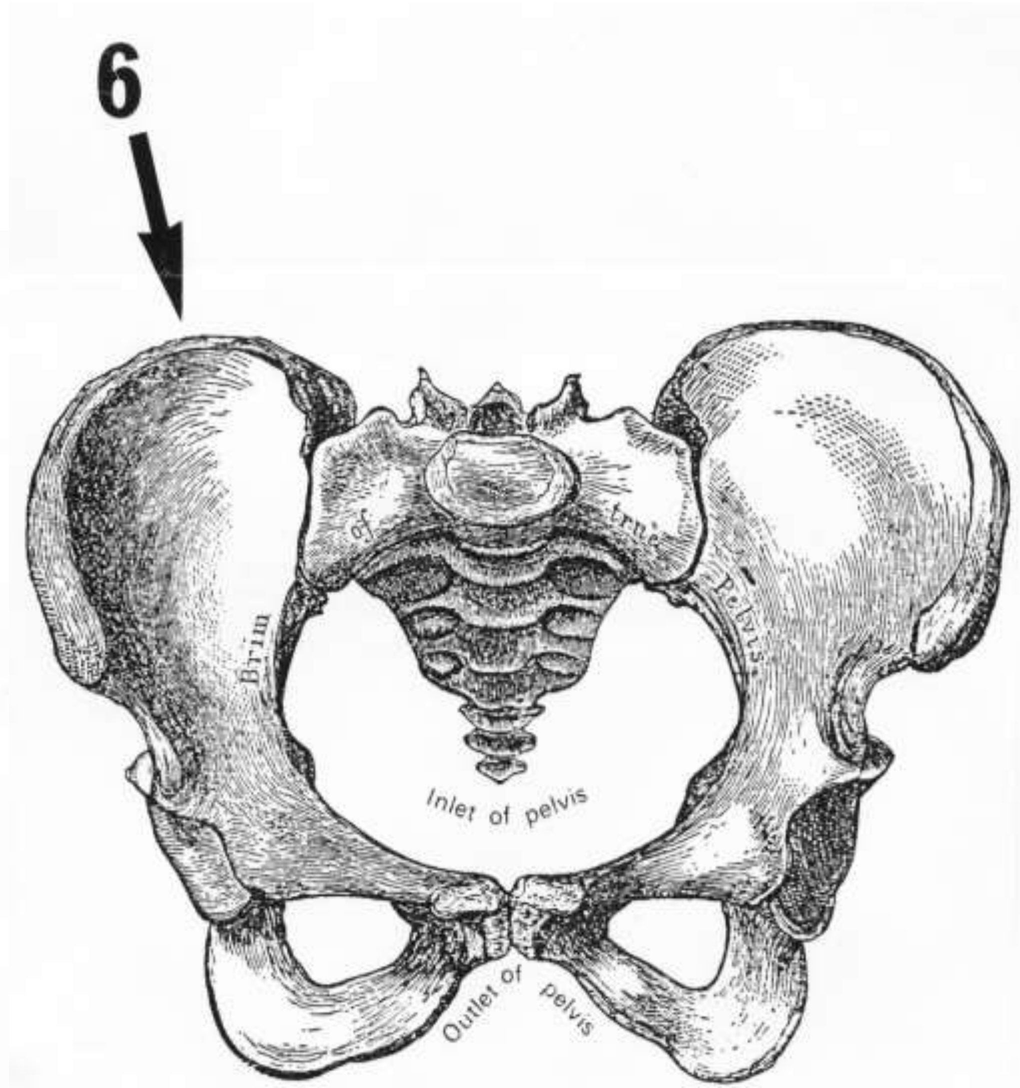
3 – acromion



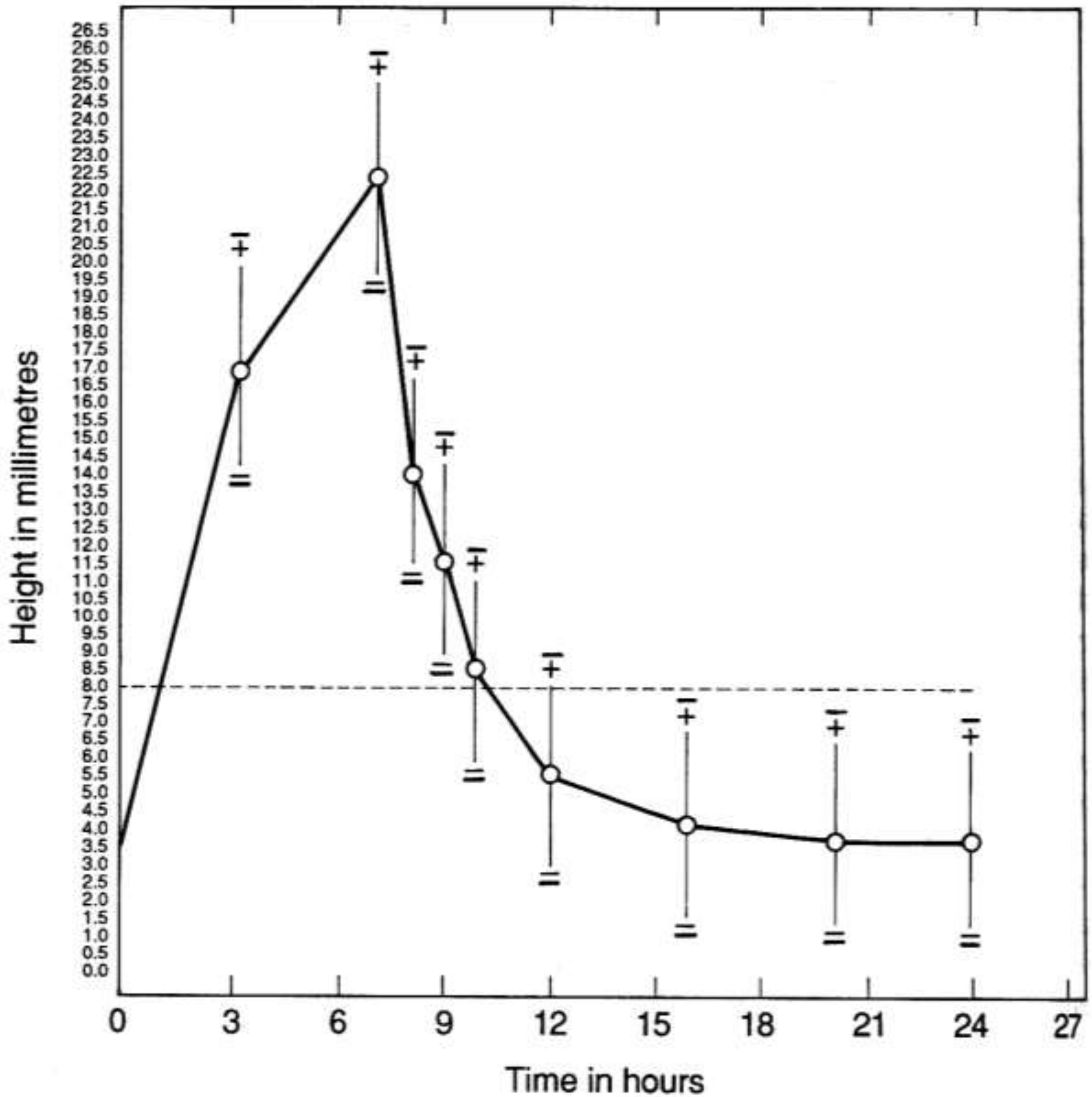
Anthropometric Measurement Example

6 – highest point of illiac crest





Measurements Which Span Articulations



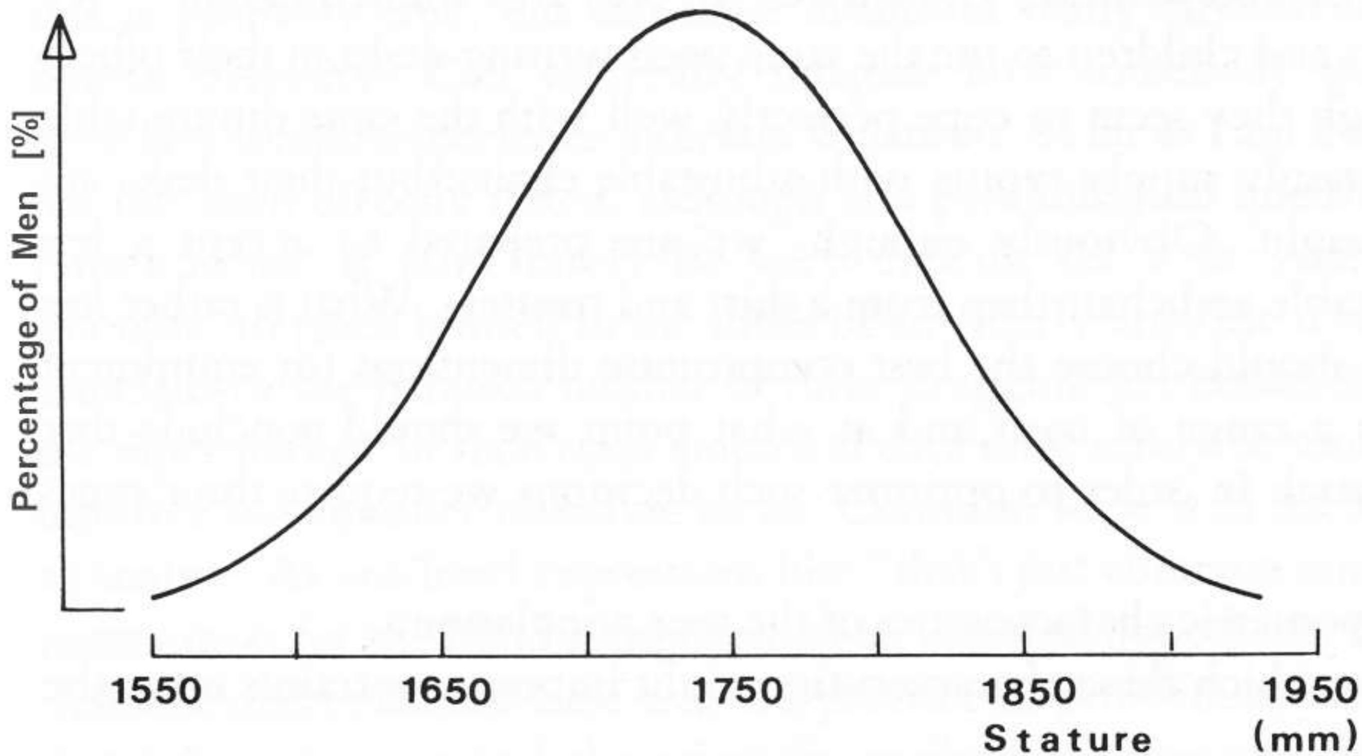
Any measurement which spans an articulation will change depending on factors such as the posture, the muscle tension and the time of the day.

The spine with its many articulations is a case in point.

The intervertebral disks continuously lose fluid under compressive gravity loading, leading to a reduction in thickness.

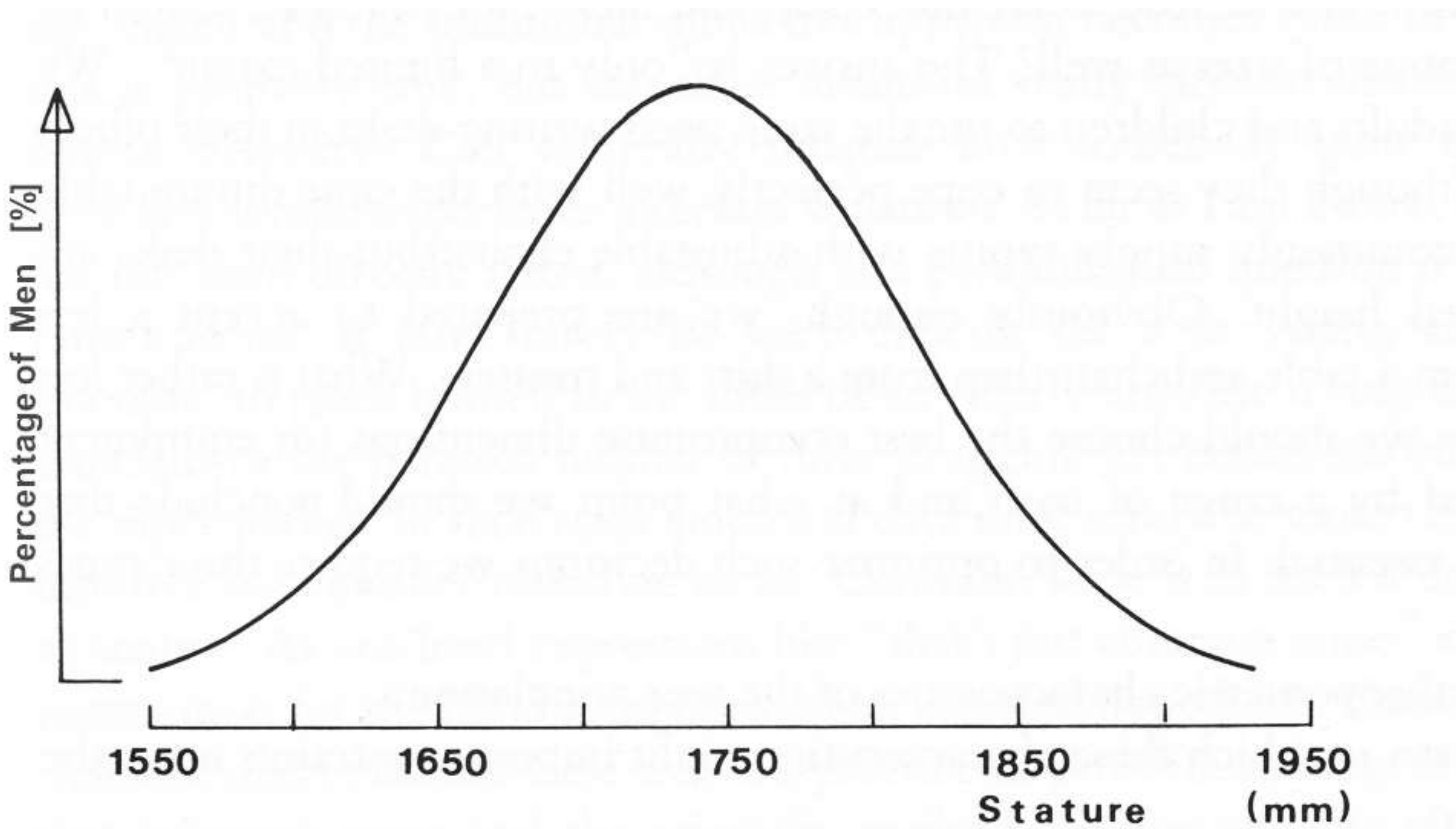
Over the day this changes the stature by more than 2 cm.

Statistical Properties of Anthropometric Data



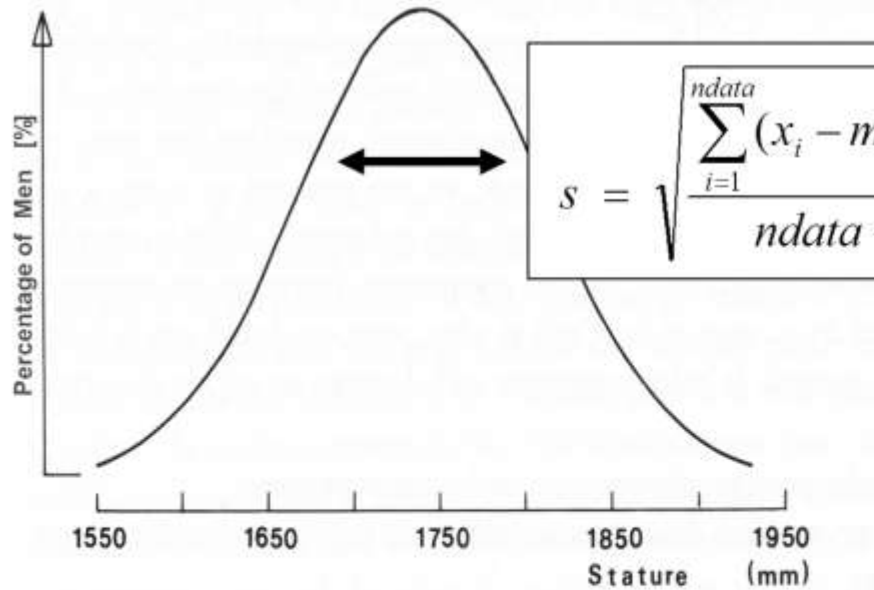
For most anthropometric properties a graph of the relative frequency of the various possible values will produce a bell shaped curve.

Statistical Properties of Anthropometric Data



Because of its generality it is often called the *normal distribution*. Another commonly used name is the *Gaussian distribution* in honour of the German mathematician and physicist Johann Gauss (1777-1855) who first described it in the context of random measurement errors.

Statistical Properties of Anthropometric Data

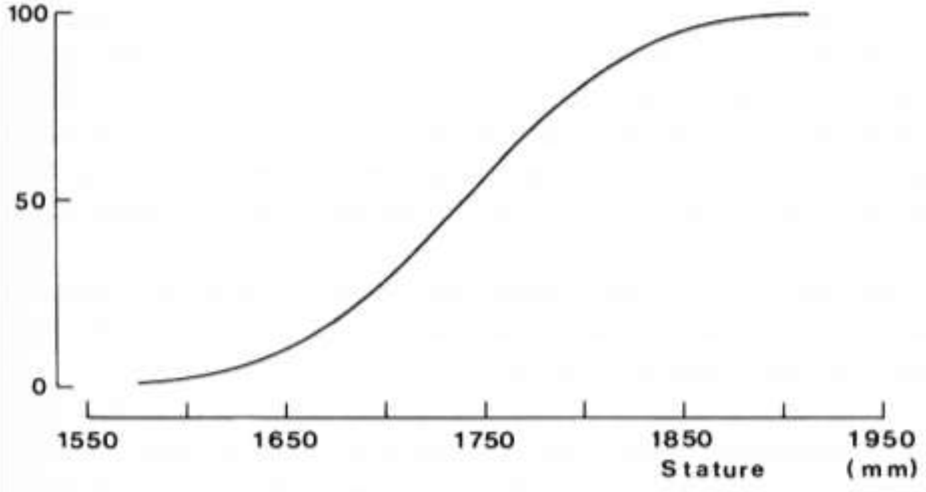


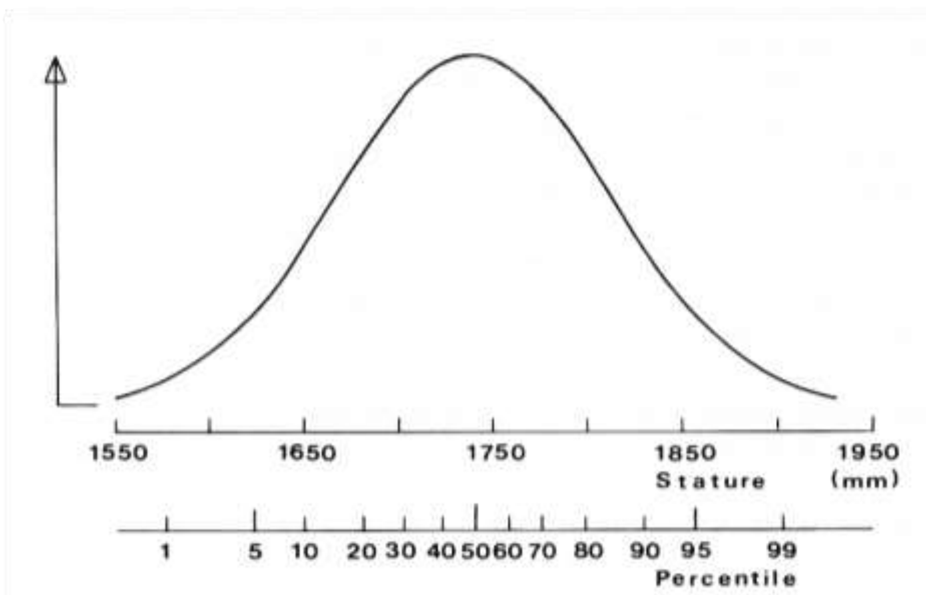
$$s = \sqrt{\frac{\sum_{i=1}^{ndata} (x_i - mean)^2}{ndata - 1}}$$

$$mean = \frac{1}{ndata} \sum_{i=1}^{ndata} x_i$$

A Gaussian distributed variable can be fully described in terms of only two fundamental parameter values, the mean and the standard deviation.

Statistical Properties of Anthropometric Data





In anthropometry it is convenient to speak of percentiles.

To say that someone's stature is 80th percentile means that the person is taller than eighty percent of the people from the same statistical sample.

Statistical Properties of Anthropometric Data

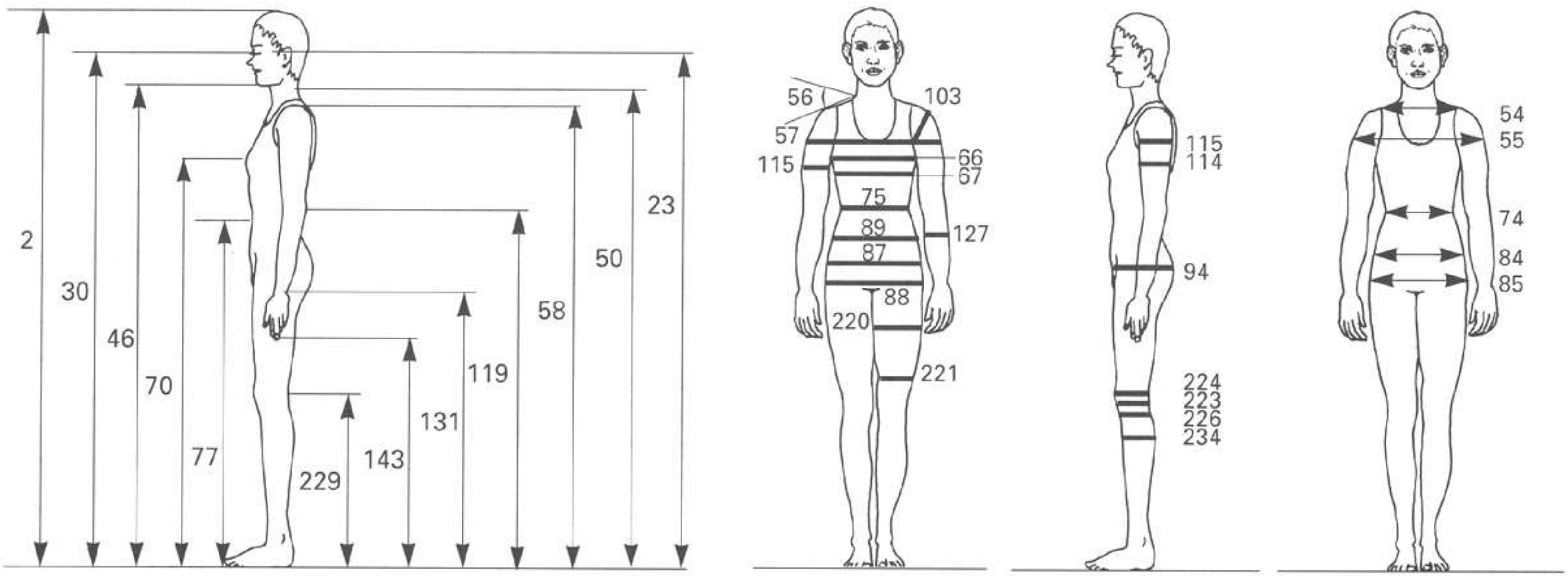
$$X_{percentile} = mean + s\,z$$

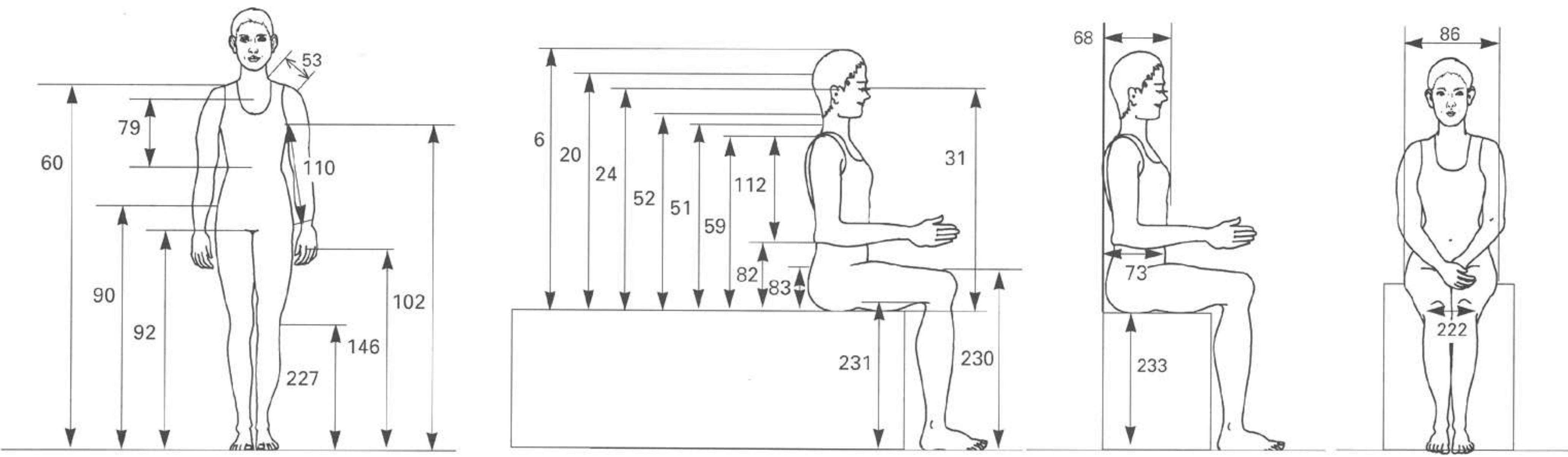
p	*z*	*p*	*z*	*p*	*z*	*p*	*z*
1	−2·33	26	−0·64	51	0·03	76	0·71
2	−2·05	27	−0·61	52	0·05	77	0·74
3	−1·88	28	−0·58	53	0·08	78	0·77
4	−1·75	29	−0·55	54	0·10	79	0·81
5	−1·64	30	−0·52	55	0·13	80	0·84
6	−1·55	31	−0·50	56	0·15	81	0·88
7	−1·48	32	−0·47	57	0·18	82	0·92
8	−1·41	33	−0·44	58	0·20	83	0·95
9	−1·34	34	−0·41	59	0·23	84	0·99
10	−1·28	35	−0·39	60	0·25	85	1·04
11	−1·23	36	−0·36	61	0·28	86	1·08
12	−1·18	37	−0·33	62	0·31	87	1·13
13	−1·13	38	−0·31	63	0·33	88	1·18
14	−1·08	39	−0·28	64	0·36	89	1·23
15	−1·04	40	−0·25	65	0·39	90	1·28
16	−0·99	41	−0·23	66	0·41	91	1·34
17	−0·95	42	−0·20	67	0·44	92	1·41
18	−0·92	43	−0·18	68	0·47	93	1·48
19	−0·88	44	−0·15	69	0·50	94	1·55
20	−0·84	45	−0·13	70	0·52	95	1·64
21	−0·81	46	−0·10	71	0·55	96	1·75
22	−0·77	47	−0·08	72	0·58	97	1·88
23	−0·74	48	−0·05	73	0·61	98	2·05
24	−0·71	49	−0·03	74	0·64	99	2·33
25	−0·67	50	0	75	0·67		

The value of an anthropometric variable can be determined for any percentile using the mean value, the standard deviation and a statistical table containing what are called normalised "z scores".

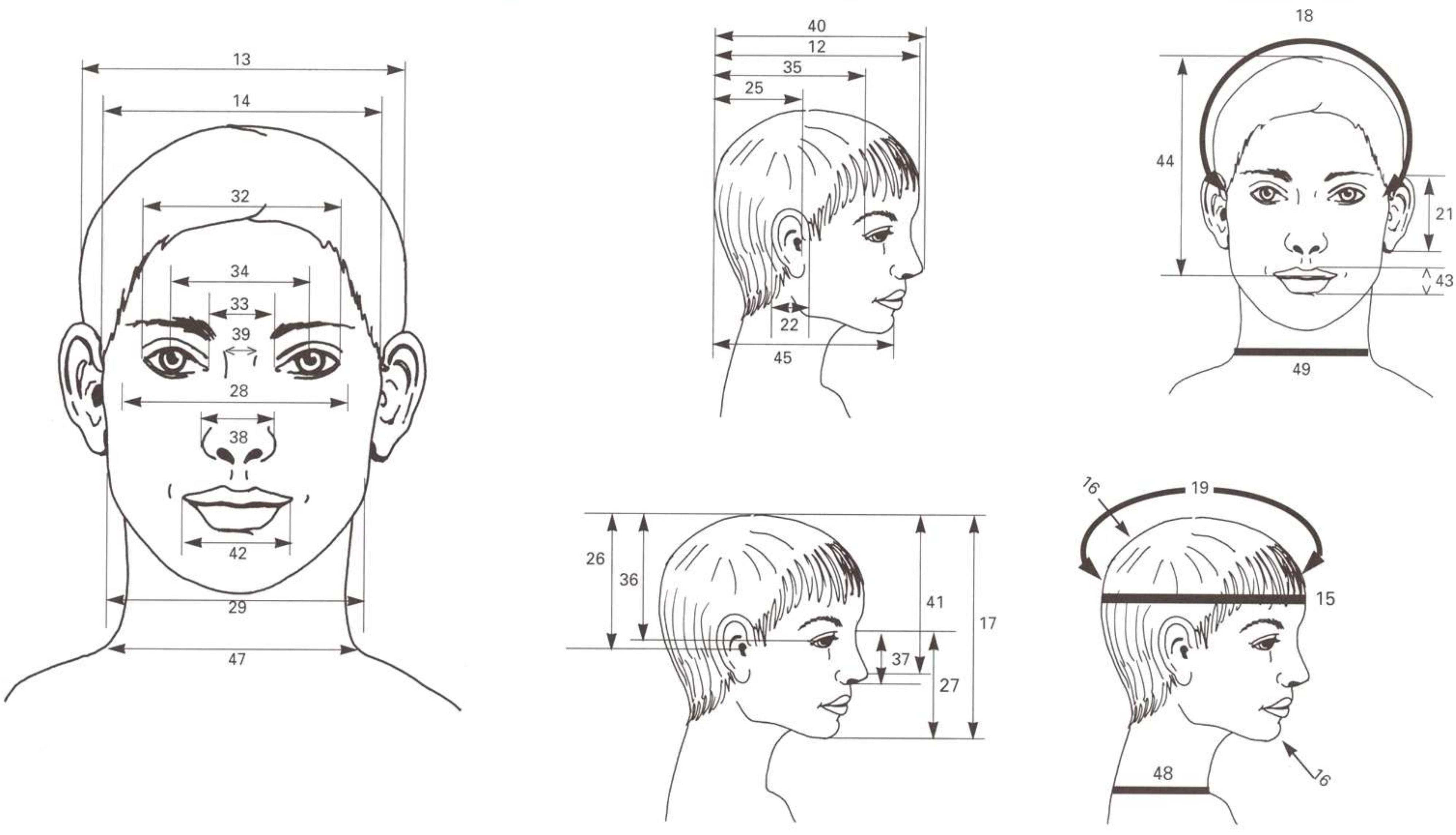
Anthropometric measurements

The following diagrams are a guide to the anthropometric measurements contained in the Handbook.
All of the measurements are shown here except sitting height (slumped).

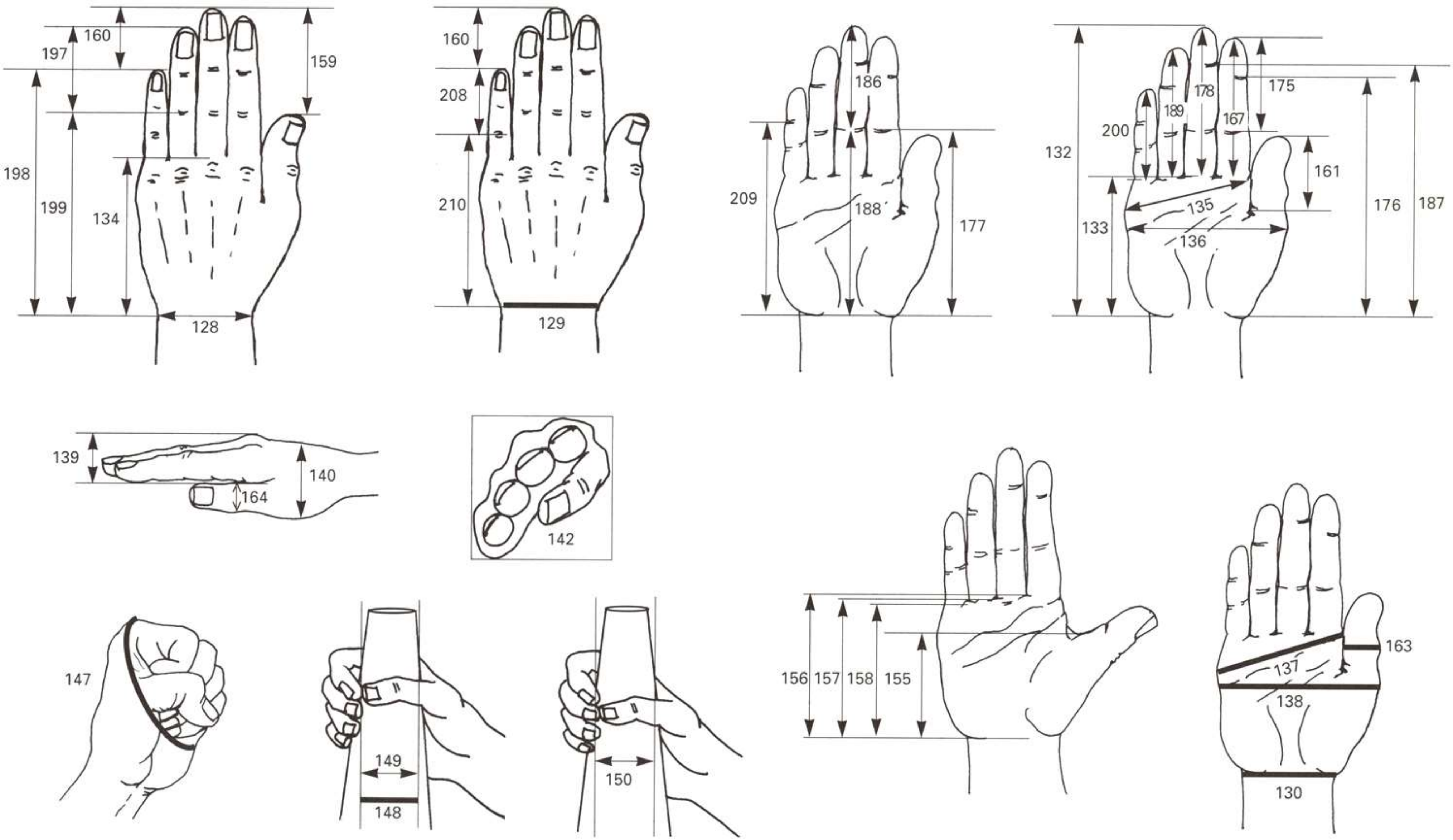




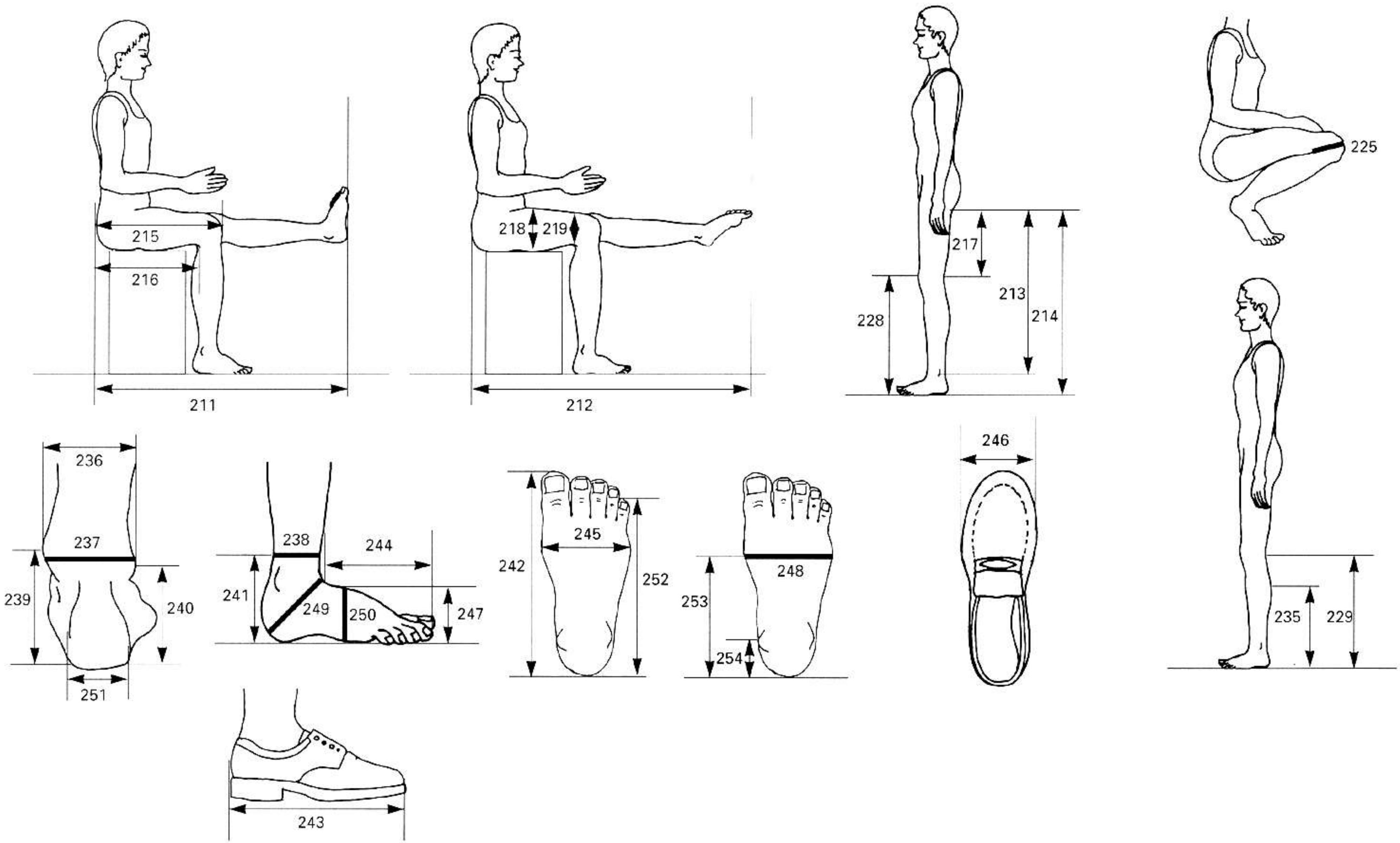
Anthropometric measurements



Anthropometric measurements



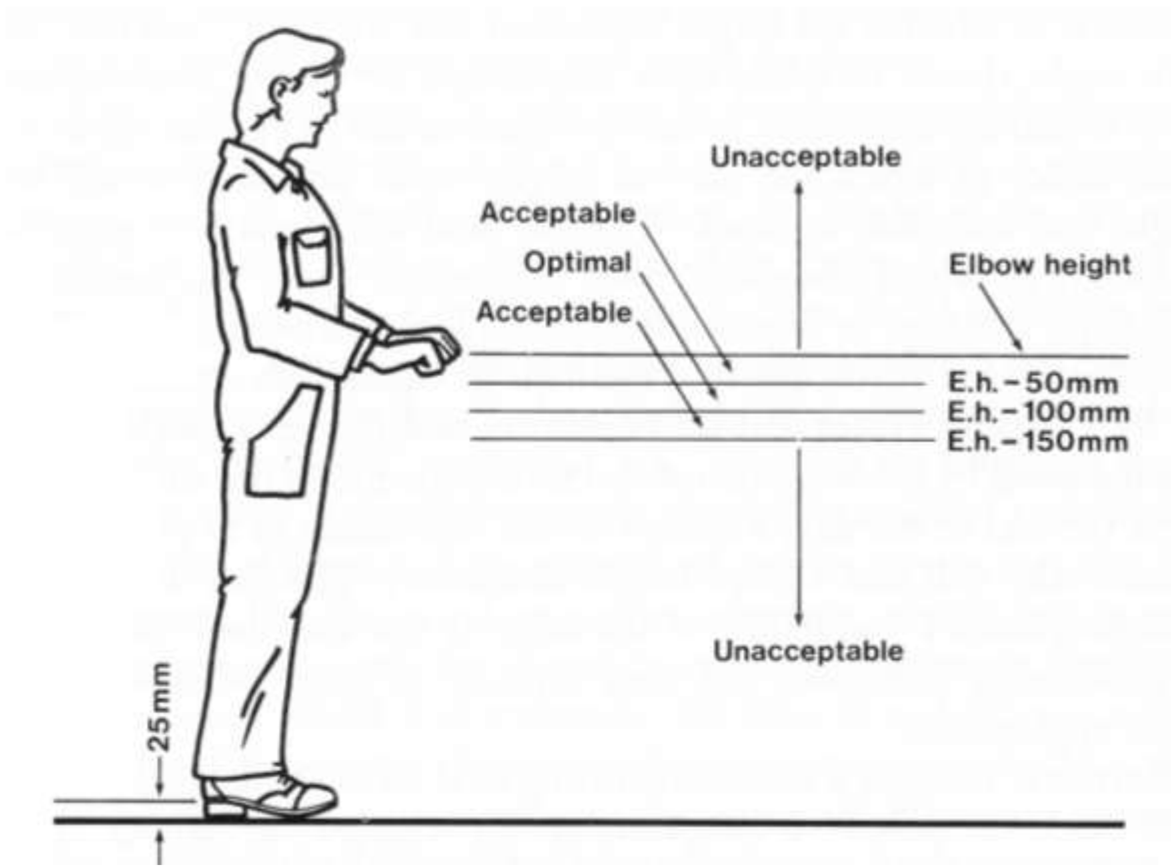
Anthropometric measurements



Use of Anthropometric Data in Design

design scenario	aim	examples	design should accommodate:	critical design scenarios:
fit	design to ensure user- product match and appropriate and effective use	bicycles, cycle helmets, car restraints, seats	maximum range of the population **eg 5th to 95th %ile***	**use both maximum and minimum expected values**
reach	placement to ensure access and appropriate and effective use	position of handrails & controls	smallest of population **eg 5th %ile***	**use minimum expected value**
clearance	placement to avoid undesirable or unintentional contact	access hatches, desk-seat gap	largest of population **eg 95th %ile***	**use maximum expected value**
posture	design to ensure comfortable and safe posture is adopted	working surface height, position of VDU	maximum range of the population **eg 5th to 95th %ile***	**use maximum and minimum expected values**
strength	design to ensure operability	bottle tops, jar lids, machine controls	smallest of population **eg 5th %ile***	**use minimum expected value**
entrapment	avoid unintentional retention of the whole body or body parts	railings, washing machines, ladders, banisters	largest of population **eg 95th %ile***	**use maximum expected value**
exclusion	ensure inaccessibility and inoperability	barriers, railings, guards	maximum range of the population **eg 5th to 95th %ile***	**use maximum and minimum expected values**

Use of Anthropometric Data in Design



The recommended design criteria for manual tasks is to keep the object 50 to 100 mm below the height of the elbow.

What table height should be specified for use in the workplace in the United Kingdom ?

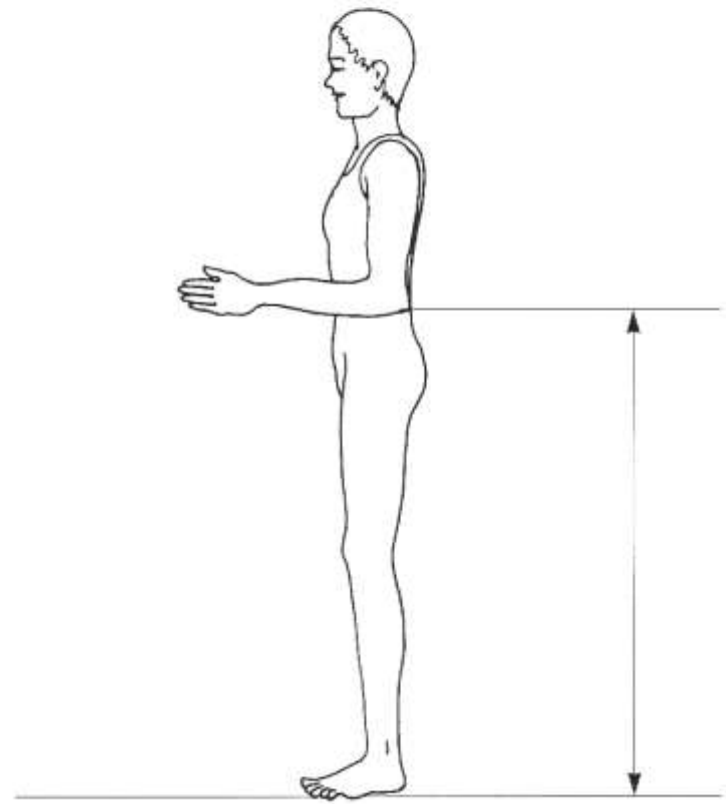
Use of Anthropometric Data in Design

A source such as the *DTI* publication ADULTDATA can be used to find the values for the elbow height of UK men and women.

In ADULTDATA elbow height is catalogued as reference measurement number 120.

ELBOW HEIGHT 120

to underside of flexed forearm, standing



Definition

Measured vertically from the floor to the bony tip of the flexed elbow. The person stands erect. This gives a slightly shorter measurement than with the arm straight.

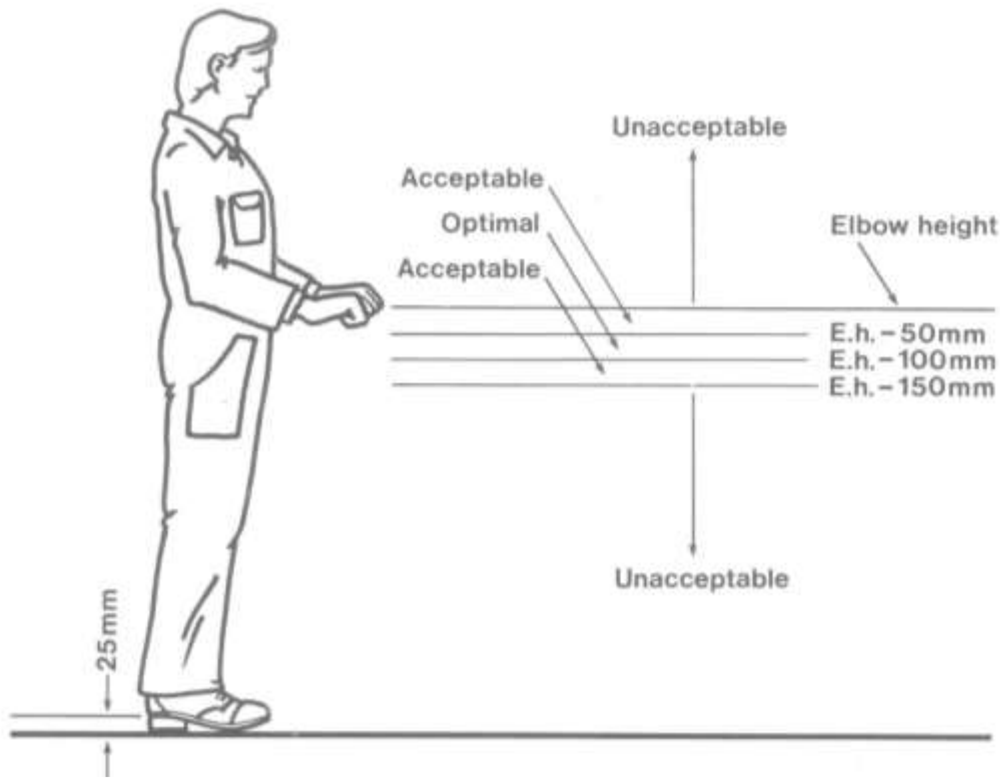
Use of Anthropometric Data in Design

Country	Sex	Mean	sd	5th%ile	95th%ile	Source
UK	m	1095.6	49.9	1013.5	1177.8	PeopleSize 1998
	f	996.2	47.8	917.6	1074.8	PeopleSize 1998
Japan	m	1046.4	41.3	978.5	1114.3	PeopleSize 1998
	f	963.9	33.5	908.7	1019.1	PeopleSize 1998
Sri Lanka	m	1014	70.04	929	1100	Abeysekera & Shahnavaz 1987
	f	941	62.11	873	1016	Abeysekera & Shahnavaz 1987
USA	m	1098.9	50.7	1015.5	1182.4	PeopleSize 1998
	f	1000.3	52.0	914.6	1085.9	PeopleSize 1998

From the *DTI* publication ADULTDATA, the 5th, 50th and 95th percentile values for the elbow height of UK men and women can be determined.

An optimal design might be to fit people from a 5th percentile female (917.6 mm) to a 95th percentile male (1177.8 mm).

Use of Anthropometric Data in Design



If table height cannot be made adjustable a compromise solution is to choose a table height which is 20 mm below the elbow of the 5th percentile female wearing a working shoe of average height

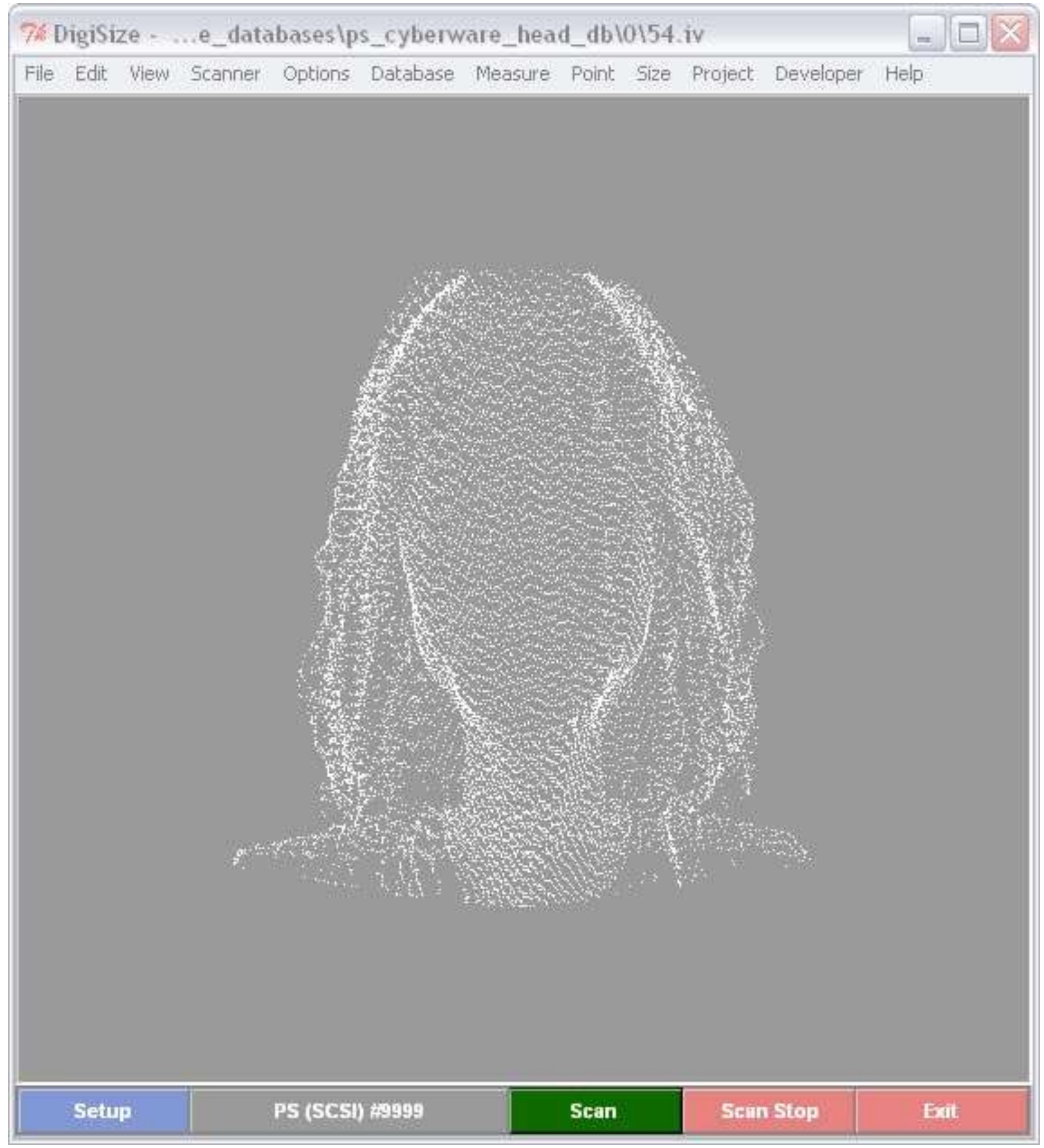
917.2 mm – 20 mm + 25 mm = 922.2 mm

This would place the table just below the elbow of a 5th percentile female and 255.6 mm below a 95th percentile male.

Anthropometric Measurement Tools

A variety of digitizing tools are in routine use for the design of items such as clothing, shoes, helmets, work tools and machine cockpits.

Anthropometric Measurement Tools



Low power lasers form the basis of several commercial 3D whole-body scanners.

Anthropometric Measurement Tools

Several steriophotogrammetric systems are currently available on the market.

Design Classic: Band Aid Adhesive Strips

Band Aid adhesive strips were created in 1920 by Earle Dickson, a cotton buyer for Johnson & Johnson, who developed them to assist his wife Josephine with dealing with frequent minor cuts in the home.

Initially they were handmade and came in strips that were 2.5 inches wide and 18 inches long. The person would cut the strip to the needed size.

Since the target market was that of households, and mothers in specific, a variety of strip sizes were developed over time for rapid and simple use on different body parts and with people of different sizes.

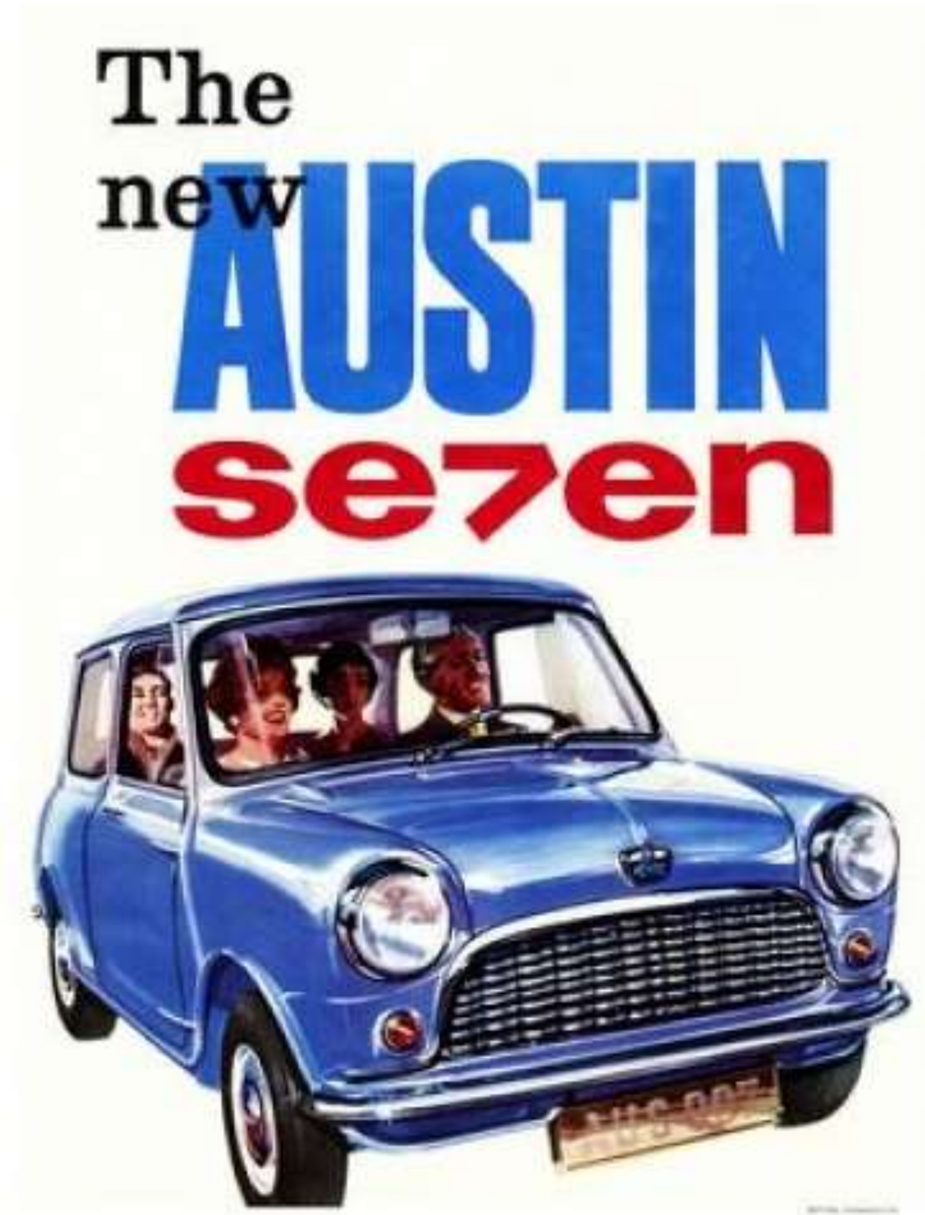
Design Classic: Austin Mini

Designed for the British Motor Corporation by Sir Alec Issigonis the Mini is considered an icon of design.

Designed around the space requirements of a family of four, its compact front-wheel drive layout allowed 80 per cent of the area of the floorpan to be used for passengers and luggage.

Initially Minis were marketed under the Austin and Morris names, as the Austin Seven and the Morris Mini Minor.

In 1999 the Mini was voted the second most influential car of the 20th century, behind the Ford Model T.



Thank you.