9

Human anthropometrics and sizing systems

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9.1 Terms and definitions

9.1.1 Anthropometrics

Anthropometrics can be defined as the science concerned with the measurement of man.[1] The name was derived from the Greek 'anthro' and 'metreein' which mean human and measure, respectively. Pheasant further expanded this definition to 'applied anthropometrics', which included numerical data concerning size, shape and other physical characteristics of human beings and could be applied in the design context .[2]

9.1.2 Anatomy

According to the *Columbia Encyclopedia*, anatomy is a branch of biology concerned with the study of body structure of various organisms, including humans. In Gray's classic publication, the term human anatomy comprises a consideration of the various structures which make up the human organism.[3]

9.1.3 Landmarks

Landmarks are located by anatomical points and grouped according to their positions on the body. This provides a predetermined order to permit greater speed in body measuring. Figure 9.1 shows 21 anatomical points[4] and Fig. 9.2 indicates 19 key landmarks.[5]

Clear landmarks with logical coding would be useful to explain all critical measurements for basic pattern development. From landmark points to body lines, all definitions and measuring methods should be standardised and commonly agreed. To obtain the data with acceptable consistency, reproducibility and reliability, structured methods of landmarking and recording will help to make the measuring process more efficient and effective.

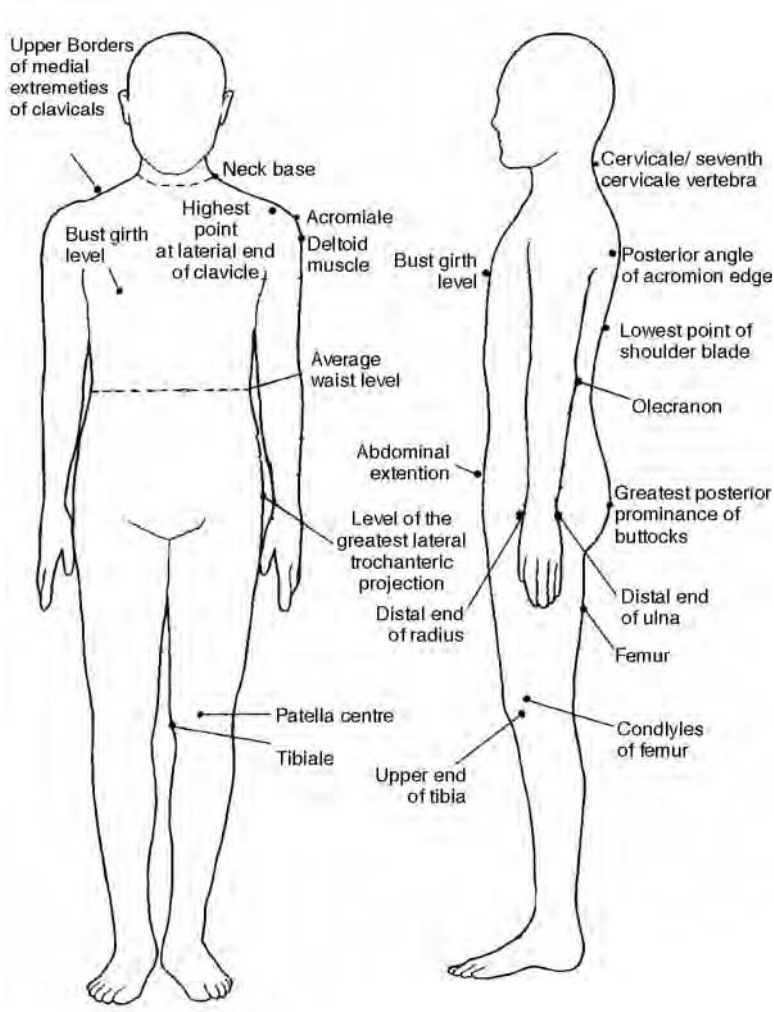


Figure 9.1 Critical anatomical points.

9.1.4 Body measurement

The classic terminologies and methods of body measurement for the clothing field were first published by the Joint Clothing Council.[4] A standard reference for body measurements was later made available.[6] Body measurements were divided into four groups: stature, segment length, body breadth and circumference. In 1996, Beazley suggested a procedure for undertaking a size survey using ISO 8559:1989 (E) which included a natural sequence of body measurement comprising three types of data: horizontal, vertical and others.[5] In Japanese Body Size Data 1992–1994, the definitions, equipment, methods and

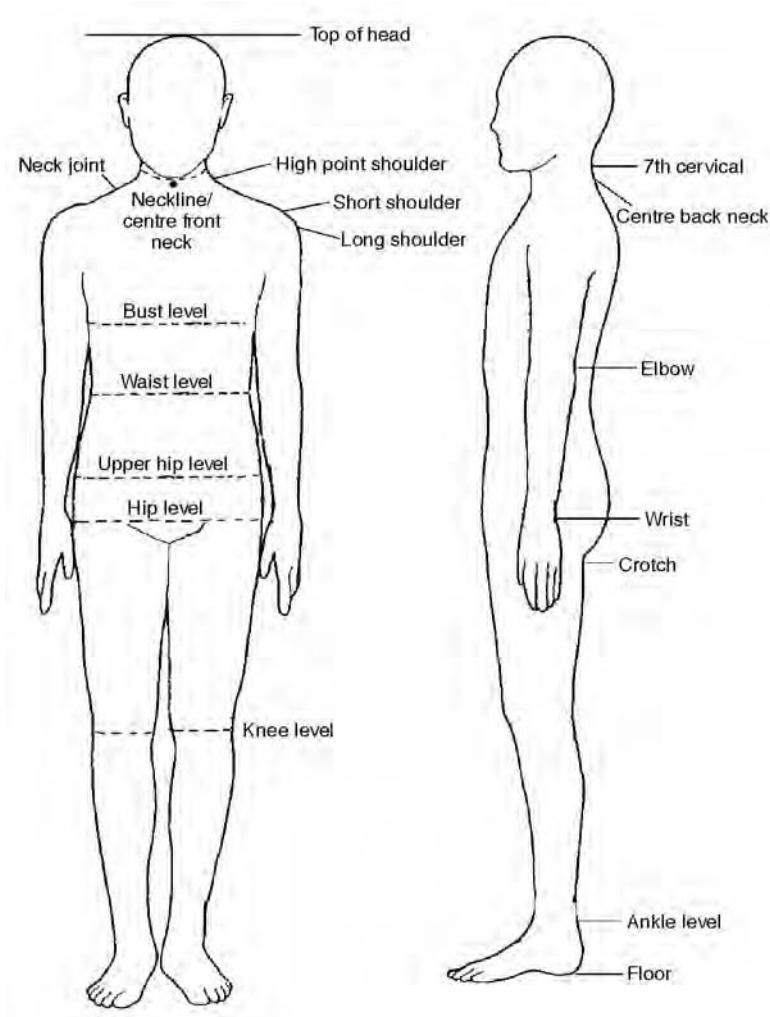


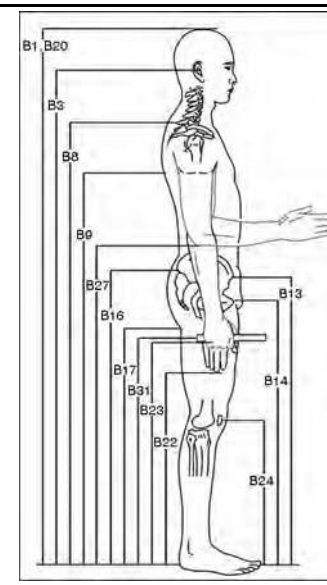
Figure 9.2 Key body landmarks.

procedures of body measurements were described in detail. An example of the vertical measurement is illustrated in Fig. 9.3.

9.2 Traditional anthropometry

A detailed account of the problems and methods of anthropometry was given by Cameron who outlined the historical development of anthropometry and gave a detailed comparison of equipment and methods of body landmarking. He also explained the dynamic relationship between subjects being measured, the measuring instruments and the measurer.[8]

Code	Measurement item	Definition of measurements
B1	Height	
B2	Entocanthion height	
B3	Tragion height	
B4	Suprasternale height	
B5	Fossa jugularis height	
	Nipple height (male) /	
B6	Bust height (female)	
B7	Substernale height (male) /	
	Underbust height (female)	
B8	Cervicale height	
B9	Axilla height	
B10	Iliocristal height	
	Height of minimum	
B11	abdominal circumference	
B12	Omphalion height	
B13	Iliospinale height	
B14	Symphysion height	
B15	Trochanterion height	
B16	Iliospinale posterius height	
B17	Gluteal furrow height	



B18	Crotch height	
B19	Acromiale height	
B20	Radiale height	
B21	Stylion height	
B22	Dactylion height	
B23	Phalangion III height	
B24	Mid-patellar height	
B25	Tibiale height	
B26	Height of calf circumference	
B27	Elbow height	
B28	Dactylion height, over head	
B29	Dactylion height, over head, heel raised	
B30	Maximum height	
B31	Fist height, grip axis	
B32	Gnathion height	
B33	Phalangion height, over head	
B34	Trunk length	

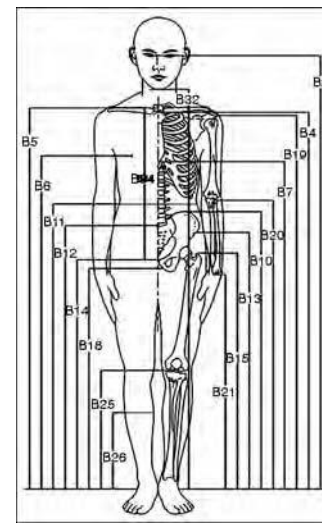


Figure 9.3 Definition of vertical body measurements. Source: Makiko Kouchi and Masaaki Mochimaru, 2002: Japanese body dimensions data 1997-1998, English version. Digital Human Laboratory, National Institute of Advanced Industrial Science and Technology.[7]

9.2.1 Anthropometric tools

Anthropometry deals with the methods of precise measurement of the human body. The methods and tools of anthropometry have been developed to make valid and reliable measures of individuals in a population for the design of clothing. The tools include anthropometers (a standing tool which measures straight linear distances), calipers, and calibrated measuring tapes. Linear heights are taken with anthropometers, while linear depths and widths are taken with calipers. Landmarks are carefully located (usually by feeling for bones beneath the skin) and marked on the body to identify anchor points for the measuring tools and to ensure that measurements are taken consistently and accurately.

9.2.2 Preparation

The environment for anthropometric measurement was suggested to be a quiet room without undue haste and the absence of unnecessary people. Before measurement, the researcher should select the measurements to be taken, acquire the correct instruments and design a recording form. The researchers who will collect the data must be trained so that they will arrive at the same measurement consistently.

9.2.3 Sampling

Identification of a representative sample of the population is critical in order to collect data which reflects the population as a whole. Age, ethnicity and body type must all be considered. Statistical methods can be used to identify a representative sample but finding subjects for every category could be challenging.

9.2.4 Challenges

Many factors come into play during the measurement of the subjects, which could be the source of numerous errors. Some important sources include posture, identification of landmarks, instrument position and orientation, and pressure exerted by the measuring instrument. Due to the difficulty in controlling all potential sources of error, true values are seldom obtained in anthropometry. Accuracy and precision of anthropometric measurements are at the mercy of the researcher who takes them.

Human errors

Manual measuring of a human body is not an easy task. Accuracy depends upon the touch and eye judgement of the researcher. The measurements may vary

with different landmarks on the body, positioning of the equipment and the tension of the tape measure.

Varied definitions
In the apparel industry, different definitions of body measurements are used in the various pattern-making methods. The differences in terminology and methods significantly impact on the measurements. Unclear landmarks of waist level can cause differing lengths and therefore result in obvious variations in fit.

Time-consuming process
Generally the collection of anthropometric data has been an extremely complex process which is time-consuming, expensive and requires skilled personnel. Recent technologies, such as 3D body scanning and automated measurement, may change this.

9.3 Historical development of sizing systems

In the latter part of the eighteenth century, most clothing was custom-made by tailors. Various sizing methods were developed by professional dressmakers and craftsmen. Their techniques for measuring and fitting their clients were unique. In the 1920s, the demand for the mass production of garments created the need for a standard sizing system. In the 1930s, mail-order houses became popular. This led to frequent returns of ill-fitting garments. Hence, a large anthropometric survey of 10,042 women was conducted to develop a sizing system for women's apparel.[9] During the last decade, very extensive data were made available for fitting general clothing as well as military wear and equipment. Specific large-scale studies are summarised chronologically below:

1901 The US federal government created the National Bureau of Standards (NBS), a non-regulatory agency, for the purpose of standardising measurements for science and industry.[10]

1902 In the Sears Catalog, dresses were coded with bust girth and age.[11]

1921 The first report was published of an American anthropometric survey with clothing sizing which was conducted on some 100,000 men during demobilisation at the end of First World War.

1937–41 A US size survey of some 147,000 boys and girls was conducted on a nationwide basis.

1939–1940 A further study on some 150,000 American women was conducted by the same team. The report entitled 'Women's measurements for garment and pattern construction' was published in 1941 by the US Department of Agriculture.

1945 The Mail Order Association of America recommended a commercial standard CS151 for the clothing industry.

1947	The British Standard Institution developed standards relating to garment sizing in a series of product standards, such as women's blouses (BS 1345).
1950s	The British Board of Trade published the results of a survey of 5000 women. It indicated that 126 sizes were required to cater for 98% of the adult female population.
1954	The Denmark Standards Association published a national standard DS923 for women's sizes.
1955–59	The Polish Academy of Science, in conjunction with the Central Laboratory of the Clothing Industry, conducted anthropometric surveys to establish a national sizing system.
1957	The United Kingdom published a report of a sizing survey collected from UK military personnel.[4]
1957–58	Germany published its first size table of body measurements.
1957–65	The former USSR carried out extensive surveys on the principal population groups, including men, women and children in various regions of the country.
1958	The US-based voluntary standard CS215-58, titled 'Body Measurements for the Sizing of Women's Patterns and Apparel', was published by NBS, based on further analysis of the 1939–40 data.[12]
1961–62	The German Research Institute conducted a survey of women for the clothing industry to produce properly fitting garments for the population.
1963	The German Hohenstein Research Institute published fairly extensive surveys for the preparation of women's and girls' outerwear size tables.
1963	The Netherlands Standards Institute (NNI) reported a standard sizing system for men's clothing.
1965–66	In France, the Centre d'Etudes Techniques des Industries de l'Habillement (CETIH) surveyed 7283 male subjects between the ages of 22 and 64.
1966	The German Textile Distributors' Association published size tables of outerwear for men and boys after a survey on some 10,000 subjects which constituted over 80,000 measurements.
1966–67	The Japanese JIS Standard reported a size survey of 35,000 subjects.
1969	CETIH in France compiled women's measurements with the exception of foundation garments. A survey was carried out on 8037 adult females between the ages of 18 and 65 years, and another on 14,000 boys and girls of 4 to 21 years of age.
1969	The first Australian survey of 11,455 women was carried out.
1970	The US Voluntary Products Sizing Standards PS 42-70 was published for commercial pattern sizing. Grading of sizes was

	arbitrarily set at 1 inch increments for girth and 1½ inch increments for height.[13]
1972	A Swedish national anthropometric survey was carried out on about 1000 subjects, and involving 40,000 measurements. This is a small sample but the population was fairly homogeneous.
1972	South Africa published a Code of Practice SABA 039 'Standard Size Ranges for Men's Clothing'.
1973	Body size tables PC 3137 and PC 3138 were published in the former USSR.
1974	The BS 3666 'Sizing Coding Scheme for Women's Outerwear' was published.
1974	China started to prepare a sizing standard for clothing, known as GB 1335–81, which was then implemented in 1981.
1975	The International Organisation for Standardisation (ISO) developed a new size labelling system with key dimensions and pictograms of figure types which would aid the consumers in size selection.[14]
1977	The Swedish Textile Research Institute (TEFO) and the Clothing Industries Federation (KIF) published a sizing system for women's garments which included market distribution charts.
1978–81	A further study was carried out in Japan on 50,000 subjects of both sexes and all ages.
1980–86	Size charts for the clothing industry in Netherlands were developed from measurements of 10,000 men and women.[15]
1981	The Chamber of Mines of South Africa Research Organisation reported an anthropometric survey on 669 black mine-workers.
1981	South Korea labelled garment sizes with arbitrary codes, but did not indicate body measurements.[16]
1981–82	Germany undertook further measurements of 10,000 women and girls.
1982	The British Standards Institution developed a series of size systems BS 3666 for women's wear, 3728 for children's wear and 5592 for men's wear.
1983	A sizing system was developed in Germany by adapting the ISO system.[17] The sample size was 9402 women and the result provided 57 sizes, catering for 80% of the female population.
1985	The Japanese JIS L4005 'Sizing Systems for Women's Garments' was published.
1986	A Hungarian standard sizing system, MSZ 6100/1, was developed.[17]
1987	To update the GB 1335-81 version for clothing applications, a Chinese national size survey was carried out to measure more than 14,000 men, women and children from ten different provinces.
1988	An anthropometric study for US army personnel, known as ANSUR, involved body measurements on 1774 men and 2208 women for the design and sizing of military clothing and equipment.[18, 19]

1989	The European Association of Clothing Industries (AEIH) provided sets of body dimensions for men and women of three height groups and six other body dimensions.
1990	A standard size labelling system was developed in South Korea.[20]
1991	A Chinese Sizing Standard GB 1335–91 was published after lengthy discussion among the clothing academia, industrialists and experts.
1992–94	34,000 Japanese people, aged from 7 to 90, were measured in two buses that travelled from south to north, equipped with a 3D body scanner.[21]
1994	The American Society of Testing and Material (ASTM) committee – published an updated standard known as D5585-94. It was not derived from new anthropometric data, but was compiled from designers' experience and market observations in the USA.[19]
1995	A survey of over 6000 women aged 55 and above was completed and found inappropriate representation of fit concerns for older women. A new standard ASTM D5586-95 was therefore established for this group.[22]
1997	The Chinese sizing standard was further updated to a new version GB 1335-97 with consideration of international practice.
1999–2002	The UK Government started a national sizing survey known as 'Size UK', using a [TC^2] 3D body scanner.[23]
2002–2003	'Size USA' commenced with similar methods and procedures as used for 'Size UK'[24] and completed the survey of 10,800 people in 13 cities across the United States in December 2003.
2004	A comprehensive national survey of 6600 men and women in Mexico is planned to be carried out, using a TC^2 body scanner.

People have changed in body shape over time. Workman[25] demonstrated that the problem of ageing contributes to the observed changes in body shape and size, more than any other single factor, such as improved diet and longer life expectancy.[26] Sizing concerns will grow as the number of ageing consumers is expected to double by the year 2030. This presents a marketing challenge for the clothing industry since poor sizing is the number one reason for returns and markdowns, resulting in substantial losses. Therefore, sizing systems have to be updated from time to time in order to ensure the correct fit of ready-to-wear apparel. Many countries have been undertaking sizing surveys in recent years.

9.4 Latest national size survey using a 3D body scanner

Along with the rapid development of a 3D body scanner, the international communities have already made headway in conducting anthropometric surveys using the state-of-the-art technologies in helping to reduce the time and labour

involved in the collection of anthropometric data. The intention is to have accurate and automated 3D body analysis information delivered to the apparel industry in a form which is immediately useful. The system measures body size, shape and volume in ways which can be customised for each apparel segment and even allows for the direct creation of garment patterns from 3D data, avoiding the interpretation step of using measurements and shape.

9.4.1 Japanese size survey (1992–1994)

Japan was probably the first country to use a 3D body scanner to conduct a large-scale national size survey. The statistical results of the survey are available in *Japanese Body Size Data 1992–1994*, published by the Research Institute of Human Engineering for Quality Life (HQL). About 19,000 Japanese males and 15,000 females aged from 7 to 90 were measured. Some 178 measurement items were obtained from the Voxelan laser 3D body scanner and traditional methods.

The major motivation for this sizing survey was to understand the changes that have occurred in body size and shape in Japan. It revealed that human stature decreased after the Kofun period, and was shortest at the end of the Edo period. Since then, it has increased very rapidly. The main reason for the observed changes is considered to be environmental factors relating to nutrition, rather than to genetic factors. Figure 9.4 shows the relation between the birth year and the mean stature of people aged 20. The mean stature of Japanese people has increased by more than 10 cm over the last 100 years. The rate of increase was especially high for the generation born in the 1940s, and became very low for the generation born in the 1970s. The inter-generation differences in stature are partly due to ageing, although the older generation was shorter than the younger generation even when they were young adults.

9.4.2 CAESAR (1998–2002)

The Working Group of the CAESAR project (Civilian American and European Surface Anthropometry Resource) consisted of the Computerised Anthropometric Research and Development Laboratory at Wright Patterson Air Force Base, the National Research Council from Ottawa, Canada, Iowa University, Department of Human Sciences at Loughborough University, and TNO. It used Cyberware's whole body scanner technology and funds from companies who each contributed US$40,000. The Working Group collected over 10,000 scans in North America and Italy. The subjects comprised various weights, ethnic groups, gender, geographic regions and socio-economic status. The survey included three laser scans per person, one standing and two in a sitting position (Fig. 9.5), as well as 40 traditional body measurements taken with a tape measure and calliper.

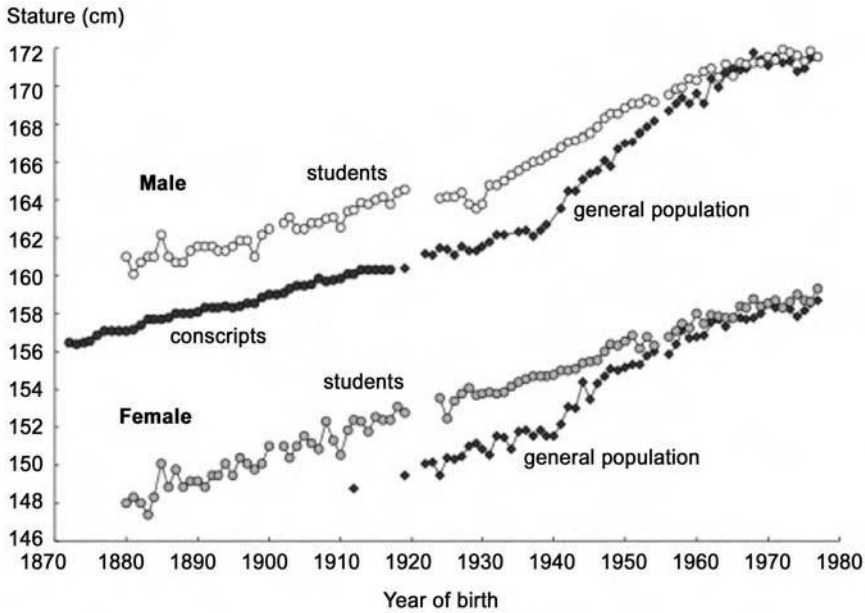


Figure 9.4 The year of birth versus the average stature of Japanese people aged 20. Source: Makiko Kouchi, 1996: Secular change and socio-economic difference in height in Japan. Anthropological Science, 104: 325–340.[27]

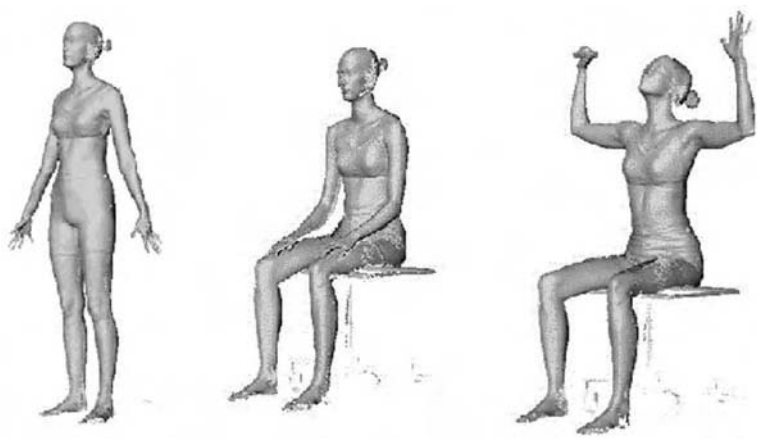


Figure 9.5 Three measuring postures. Source: Robinette, K., Blackwell, S., Daanen, H., Fleming, Boehmer, M., Brill, T., Hoeferlin, D., and Burnsides, D., (2002) Civilian American and European Surface Anthropometry Resource (CAESAR), Final Report, Volume I: Summary, AFRL-HE-WP-TR-2002-0169, United States Air Force Research Laboratory, Human Effectiveness Directorate, Crew System Interface Division, 2255 H Street, Wright-Patterson AFB OH 45433-7022.[28]

9.4.3 Nedscan (2000–2002)

Over the last fifty years, the Dutch people in the Netherlands have gained about 8 cm in height. The average height of 1.84 m for a male and 1.71 m for a female make them the tallest in the western world and they are still increasing in stature. Therefore, exact body dimensions are necessary to design and develop products which fit them and thereby improve the products of the apparel industry.

NedScan was a part of the CAESAR project, measuring the body dimensions of the Dutch population. In August 1999, the NedScan project started with over 2000 subjects in Soesterberg and planned to finish measurements in the Netherlands in September 2000. They then started measurements in Italy from June 2000 to 2002. TNO used the Cyberware 3D body scanner to take measurements of 42 body parts of 1255 Dutch men and women aged between 18 and 65.[29]

9.4.4 Size UK (1999–2002)

In 1999, the UK government launched a national research project and established the Centre for 3D Electronic Commerce. The project was sponsored by a group of commercial companies and leading clothing retailers. The project had three main parts: virtual shopping, custom clothing and the UK national sizing survey which is known as 'Size UK'. It was the largest and the first national survey in the UK since the 1950s. The cost of the UK Sizing Survey has been stated as $1.2 million. Three TC^2 body scanners were used in eight different locations around the UK. Over 140 measurements were automatically extracted for each subject, requiring only ten measurements to be taken manually.

Size UK demonstrates the use of 3D body scanning in a large-scale 3D size survey, with the aim of providing consumers with better fitting clothes. The London College of London and University College London have played a major role in the project, and a total of 10,000 women and men were scanned.

Bodymetrics was selected to be the exclusive seller for the National Sizing Survey data obtained from 'Size UK' in 2003. Therefore it is now responsible for analysing the body data of 5000 women and 5000 men and marketing the research data. From the analysed 3D shape data, the services to be offered include virtual try-on, and the supply of size charts and tailor dummies. They are also involved in the Body Craze program in Selfridges which has installed a TC^2 body scanner which scans its customers and digitally matches them with their ideal jeans. The results are fed into a denim data bank containing details of famous brands, such as Calvin Klein, D&G and Versace.

9.4.5 Size USA (2002–2003)

Following successful experience with the TC^2 body scanner in the Size UK survey, Size USA[30] has been able to use the same technology[31] in the American national size survey. It completed 10,800 scans of subjects by 16 December 2003. Top-level sponsors are being granted access to the initial survey data in quarterly increments. Apparel products influenced by the Size USA results already appeared on the market during 2003.

9.4.6 African body dimensions (2004–onward)

African body dimensions (ABD)[32] was a joint venture initiative to establish a South African national anthropometric database to address the specific requirements in the areas of clothing size and fit. Ergonomics Technologies and the University of Potchefstroom are the custodians of the South African National Defence Force (SANDF) anthropometric database, currently the largest South African anthropometric database and possibly the largest in Africa. The University of Pretoria hosted the Clothing Size and Fit Symposium held in 2000, which was the springboard that eventually led to the ABD initiative. A whole body scanner was housed in a mobile unit to allow measurements to take place all over the country. The requirements from the clothing and textile industry have become more urgent as the demographics of the consumer have changed rapidly within South Africa in recent years due to globalisation, growth in the informal market and the emergence of new consumer profiles.[33] The clothing and textile industry has recognised the need for a national South African anthropometric database and has excellent insight into the problems that arise in producing garments which are designed to provide a satisfactory fit for the diversity of consumers.

9.4.7 Women's size survey in mainland China

Donghua University has jointly established a Human Science Research and Development Centre in Shanghai with the Wacoal Corporation. During 1997–1999, 1100 Chinese women were measured with their upper body naked.[34] During 1999–2000, Zhang undertook a research project 'Body Shape Study for the Comparison between Korea and China' for Seoul University.[35] 2800 women from East, North and South China were surveyed up until 2002, using traditional Martin measuring techniques. Sixty-two body positions were considered and 12 body parameters were drawn of the female torso. A silhouetter and the American TC^2 non-contact body scanner were also applied in the survey.[36] A specially-made Voxelan 3D laser scanner was also installed in 2004 for the detailed measurement of the bust region.

In the Beijing Institute of Clothing Technology, a Human Engineering Research Centre was established in 1999. A comparison of body types between Chinese and Korean college women was carried out.[37] In 2003, a size survey of Chinese women was undertaken in collaboration with a local lingerie brand. A Japanese Voxelan 3D laser scanner was installed towards the end of 2003.

9.5 International sizing

9.5.1 National size designations

Many countries have conducted large-scale size surveys on a national basis, and have revised their size standards several times. The most updated size designations are summarised in Table 9.1.

9.5.2 Standardisation of sizing systems

International Organisation for Standardisation (ISO)

Since sizing practices vary from country to country, in 1968 Sweden originated the first official approach to the International Organisation for Standardisation (ISO) on the subject of sizing of clothing, it being in the interest of the general public that an international system be created. Sweden suggested a discussion on the terminology and definitions, dimensions and tolerances, and selection of sizes. The ISO then set up a new technical committee TC133 entitled 'Sizing

Table 9.1 Examples of latest size designations in various countries

Country	Last update	National standard	Body measurements			
			Men	Women	Children	Infants
Australia	1997	AS 1182		✓	✓	✓
Canada	1992	CGSB 49.5-M85-CAN/CGSB		✓	✓	✓
China	1997	CSIC GB/T 1335.1-97	✓	✓	✓	
France	1987	NF G03-008	✓	✓	✓	
Germany	2002	DIN EN 13402		✓		
Hungary	1986	MSZ 6100/1	✓	✓		
Japan	2001	JIS L4001 to 4005	✓	✓	✓	✓
Korea	1990	KS K0050 to 0052	✓	✓	✓	✓
New Zealand	1973	NZS 8774, 5	✓	✓		
Philippines	1988	BPS 114		✓	✓	✓
Singapore	1982	PSB SS262 part 1–6	✓	✓	✓	✓
Slovak	1981	SUTN STN 80 5023	✓	✓	✓	
South Africa	1982	SABS 039	✓			✓
Spain	1974	UNE-40229 to 31	✓	✓	✓	
UK	1989	BSI BS 3666	✓	✓	✓	✓
USA	2001	ASTM D 4910	✓	✓	✓	✓
ISO	1991	ISO/TR 10652	✓	✓	✓	✓

Systems and Designations for Clothes'. There were 17 country members participating actively in the work and the committee had its first formal meeting in 1970.[38]

After lengthy discussions and many proposals, the term 'Mondoform' was agreed on as a suitable title to cover size designation implementation work. At the completion of the fifth meeting in 1979, members submitted documents relating to secondary body dimensions, their definitions and methods of measuring. This eventually resulted in the publication of ISO 8559 'Garment Construction and Anthropometric Surveys – Body Dimension', which is currently used as an international standard for all types of size survey.[39] The ISO is now a worldwide federation of national standards bodies from more than 140 countries. The latest version of international standard for clothes is found in ISO/TR 10652:1991.

The ISO system suggested describing garment sizes in a 'pictogram' in which an illustration of key dimensions is shown. These size-labelling systems will let consumers select their garment sizes by comparing their measured body size with that labelled on the garment. It is expected that consumers will be able to find their correct garment size easily without trying on too many garments. The system will also reduce manufacturers' and retailers' costs associated with the frequent returns of ordered garments and damaged garments after fitting trials.

European size standard

Further attempts to establish a uniform European size designation have been made by several organisations, these only being found in the literature, and not in practice.[40] In 1994, the first steps towards a European standard in TC 248 failed. In a second attempt in 1996 the Working Group was set up with experts from 12 countries. It revised the Mondoform to such an extent that important body measurements (height, waist and hips) could be associated, in a more flexible manner, with size series. For cost and logistical reasons, agreement has been reached on the fact that the code must not consist of more than three digits. A four-part standard (EN 13402) has been drawn up:

Part 1: Definition of the uniform body measuring procedure, and the corresponding measuring positions on the basis of pictograms.
Part 2: Agreed primary and secondary dimensions.
Part 3: Appropriate starting points and intervals between individual sizes.
Part 4: For committee agreement if there is a system compliance.

The corresponding standard was fully approved in 2003 and was published in 2004.[40]

Acceptance of standard sizing systems

Body shapes and proportions may differ significantly. Body shapes vary not only from country to country but also within countries. It might not be feasible

to construct a single set of body sizes which could be universally applied. What has been developed is a systematic format which is sufficiently open and flexible to cater for this variability, and uses certain preferred numbers and fixed intervals to render it internationally applicable. This commonality will make sizes recognisable and comparable around the world.[41]

Although the standards were reissued and updated periodically, manufacturers preferred having flexibility to change measurements quickly to suit consumer needs without reference to rigid standards.[42] According to LaBat and Delong,[26] manufacturers have resisted accepting the US sizing code. They preferred to define their own target markets through small consumer surveys. Department stores, such as Sears, J.C. Penney, Montgomery Ward and Spiegel, have developed their own specifications, better to satisfy the needs of their specific buying public. However, commercial data were collected from narrow company-specific populations and the data remained confidential.[43]

Another commercial practice is to use commercial dress forms for initial style development, the body being assumed to be symmetrical and balanced with standard body proportions. Yet these could not represent the average person in the population. Fit models play a critical role in sizing, once initial sample garments constructed from the dress forms are adjusted to the specifications of a fit model, before production begins. These specifications affect all sizes, since garments are graded from the fit model size. Goldsberry *et al*.[22] revealed that the size specifications for fit models have changed less than actual body measurements in the population.

Different manufacturers have had different size-defining systems. Even for the same size code, body measurements have changed over time. Consumers are dissatisfied with the search process needed to identify their sizes.[44] Some clothing manufacturers and retailers even deliberately downsized clothing codes from a larger size to a smaller size, in order to promote sales by appealing to customers who felt happier with smaller sizes. It brought confused sizing into the market.

To conclude, manufacturers in most countries are slowly adopting size standards and each continues to have its own specific size chart. This creates some questions[17] concerning the sizing system:

- Is the classification and selection of key dimensions reasonably done?
- Do consumers in various countries prefer to use a common sizing system?
- Are consumers able to use a sizing system which includes a list of body measurements?

9.6 Principles of sizing systems

Problems with regard to clothing sizing and fit continue to be identified globally for consumers.[33,45–48] Manufacturers and retailers incur excessive costs due to

poor prediction of stock levels.[49] Solutions can be addressed more effectively with the application of interpreted data from a national anthropometric database and sizing system.

9.6.1 Important aspects

In 1975, French suggested that sizing should have three principal aspects:[14]

1. Relationship between one dimension and another in a particular garment.
2. Size intervals by which one garment is larger than the *next* smaller garment.
3. What the size should be called, so as to identify it.

In 1993, Chun-Yoon and Jasper reviewed the sizing systems of several countries, giving detailed examples[17] according to:

- how they defined figure types
- how they described garment sizes
- which key dimensions are used for the sizing system
- how they grouped garment types.

In 1997, Winks[38] concluded that the essential elements of a sizing system comprised:

- predetermined size ranges
- specified size intervals
- a standard method of size designation
- size labelling.

The goal of any sizing system is to choose size groups in such a way that a limited number of sizes will provide ready-to-wear clothing which fits most individuals in the population. Although sizing systems developed by different countries vary in the body dimensions chosen to divide the population, the basic structure of most sizing systems is very similar.

9.6.2 Definition of figure types

To create a sizing system, the population is first divided into different body types, based on dimensions, such as height or ratios between body measurements. A set of size categories is developed, each containing a range of sizes from small to large. The size range is generally evenly distributed from the smallest to the largest size.

Women's body types
Most countries, such as England,[4] Germany[50] and Hungary,[51] developed sizing systems which classified figure types according to height and drop value. Drop value is the difference between hip and bust circumference.[17] In the UK, the

Joint Clothing Council defined three figure types according to height: short, average and tall. Within each group, five figure types were classified according to bust measurements.[4] In Germany, the height and hip types defined nine figure types. Heights were grouped into average height (normal), short (kurze) and tall (lange). Each group is divided into three hip types; slim hip type (schmalhuftig), average hip type (normalhuftig) and full hip type (starkhuftig).[50] Similarly, the Netherlands classified women's figures into three heights – 1.60 m, 1.68 m and 1.76 m, with three hip sizes – small, normal and wide. This resulted in nine sizing charts.[15] The Hungarian sizing system (MSZ 6100/1-86) defined only two female figures: normal and full, as classified by height and body-build.[51]

In the United States, early commercial standard CS215-58 defined 20 figure types according to height and hip size determined by drop values.[52] It was then revised to the product standard PS 42–70 in 1970. The figure types are classified as junior petite, junior, misses petite, misses, misses tall, women's and half-sizes. Austria sells women's wear made for two height groups: kurze (short) and normale (normal).[17] The Korean Industrial Standard Association developed a standard sizing system, which classified body figures into five height groups: 150 cm, 155 cm, 160 cm, 165 cm and 170 cm.[16] In Canada, three height groups of 155, 163 and 171 cm have three body types (junior, misses and women).[38] Czechoslovakia suggested coding the figure types as A, B and C which have drop values of 6–10 cm, 4–12 cm and 7–8 cm, respectively.

ISO developed a revised sizing system in 1991. It classified body types into A type, M type, and H type also according to the drop values (difference between bust and hip circumference) as shown in Fig. 9.6.

Men's body types

For men's wear, the body length and drop value are the two main measurements characterising the definition of figure type. Maier has compared existing sizing systems throughout the world.[40]

In the UK, BSI identified three body heights; short (166 cm), regular (174 cm) and tall (182 cm). Each has two figure types; mature (drop – 14 cm) and athletic (drop – 17 cm). The German sizing system places men's figure types into eight different categories: athletic, slim, normal, stocky, large, short stocky, large waist and short large waist as reported in Table 9.2.

In the United States, three body heights, regular, tall, and extra tall, are normally identified with two types of figure: regular and large, as reported in Table 9.3. The French identify five main body heights in cm; 162, 168, 174, 180 and 186 and seven types of figure: athletic, slim, normal, stocky, large, stout and large waisted (Table 9.4).

In Argentina, Czechoslovakia, Denmark, the Netherlands and Finland, men's figures are all categorised according to drop values. The slim figure has a drop value of 12–16 cm, while corpulent men have up to −2 to −6 cm drop.[38]

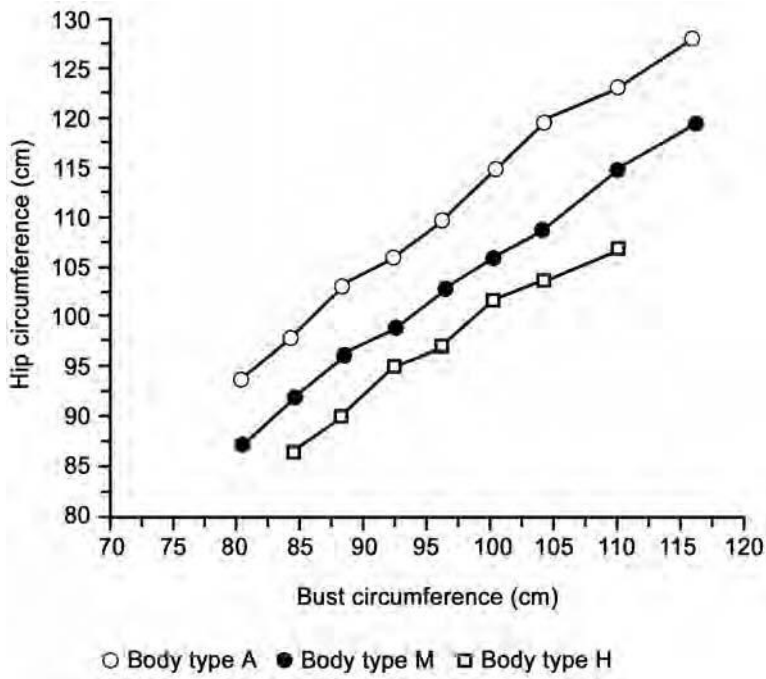


Figure 9.6 Distribution of figure types in ISO (1991). Source: Chun-Yoon and Jasper, 1993.[17]

9.6.3 Selection of key dimensions

Key body dimensions are chosen to divide the population into size groups.[19] The selection of key dimensions must satisfy the following requirements:[53]

Table 9.2 German men's figure type categorisation

Type of figure	Size making	Drop	Body height
Athletic	440–1060	−16 cm	168–190 cm
Slim	90–110	−12 cm	177–190 cm
Normal	44–58	−12 cm to −8 cm	168–186 cm
Stocky	22–29	−8 cm to −6 cm	162–180 cm
Large	144–156	−8 cm to −6 cm	168–184 cm
Short stocky	225–295	−6 cm to −4 cm	156–174 cm
Large waist	47–59	+4 cm/+6 cm/+8 cm	166–178 cm
Short large waist	495–575	+4 cm/+6 cm/+8 cm	162–170 cm

Source: Maier 2000.[40] By courtesy of Professor Angela Maier (Mrs), Dean of the Textile Department of The University of Applied Sciences, Reutlingen, Germany. Printed first by *Knitting Technology*, 22(1), p. 32.

Table 9.3 American sizing system

Sizes	Designation	Body height	Drop
S-XXL	Regular	173–182 cm	–15 cm
MT-XXLT	Tall	183–192 cm	–15 cm
MXT-3XIXT	Extra Tall	193–201 cm	–15 cm
2XL-5XL	Big Regular	173–182 cm	–10 cm
2XLT-5XLT	Big Tall	183–192 cm	–10 cm

Source: Maier 2000.[40] By courtesy of Professor Angela Maier (Mrs), Dean of the Textile Department of The University of Applied Sciences, Reutlingen, Germany. Printed first by *Knitting Technology*, 22(1), p. 32.

Table 9.4 Classification of the French tables according to types

Types of figures	Designation	Drop	Body Height in cm
Athletic sizes	Athletique	–16 cm to 14 cm	168/174/180
Slim size	Elance	–12 cm to 8 cm	180/186
Normal size	Normal	–12 cm to 8 cm	168/174/180/186
Stocky size	Fort	–8 cm to 4 cm	174/180
Large size	Trapu	–8 cm to 4 cm	162/168
Stout sizes	Corpulent	–4 cm to +/–0 cm	162/168/174
Large waist sizes	Ventru	+4 cm/+6 cm/+8 cm	162/168/174/180

Source: Maier 2000.[40] By courtesy of Professor Angela Maier (Mrs), Dean of the Textile Department of The University of Applied Sciences, Reutlingen, Germany. Printed first by *Knitting Technology*, 22(1), p. 32.

- convenient to measure
- an integral part of the garment
- have a high degree of correlation with other dimensions important in sizing
- not highly correlated with each other.

The BSI, ISO, KS and JIS systems suggest the use of different key dimensions for various garment types.[17] The Japanese example is shown in Table 9.5.

9.6.4 Designation of size labelling

Size labelling is a tool for assisting consumers to choose apparel which fits their body properly. However, garment sizes are indicated by arbitrary numbers which may represent different key measurements in different systems. Table 9.6 shows how various countries differ in the combinations of body measurements in relation to similar bust sizes of 92 cm on average.

Table 9.5 Japanese garment types and key dimensions

Garment types	Key dimensions
A. Coats, dress, and upper-body garments	Bust C, hip C*, and height
B. Skirt	Waist C, and hip C
C. Pants	
• Long pants	Waist C, hip C* and leg-inseam length
• Other pants	Waist C, and hip C*
D. Garment at work	
• Whole body garment	Bust C, and height
• Upper body garments	Bust C, and height
• Lower body garments	Waist C
E. Sweater, jacket, blouse, shirts, and sleep-wear	Bust C and height
F. Underwear (bra and foundations are excluded)	
• Whole body	
1. Slip	Bust C, and length of slip
2. Other	Bust C and hip C
• Upper body	Bust C, and underbust C
• Lower body	
1. Petticoat	Hip C. and garment length
2. Others	Hip C
G. Swimwear	Bust C, hip C

Note: Data in this table are from Japanese Industrial Standard JIS L 010, p. 8, published by Japanese Standard Association (1990).
* Hip circumference is a key dimension for fitted garment.
'C' Stands for circumference measurements

Source: Chun-Yoon and Jasper, 1993.[17]

9.6.5 Size interval

All sizing systems have both similarities and differences, although size intervals are usually classified according to height and drop value.

For women, drop value was defined as the difference between the hip circumference and the bust circumference.[17] The drop value for average women's sizes can vary from 2.5 to 8 cm, according to the particular country.

For men, Maier defined drop value as the difference between the chest and the waist measurement.[40] A comparison of the size interval and drop value for men in various countries is given in Table 9.7. In the United States, the gap between sizes is 5 cm. In Europe, size changes every 4 cm. The drop value of each size remains constant in some countries (e.g. 12 cm in Japan, 14 cm in China, 15 cm in the United States). In other countries, such as Switzerland and Scandinavia, the drop value of the smallest size is 15 cm, but it decreases by 1 cm for every one size up.

For children, countries are using age as the determinant for size. In the Fourth National Growth Study in Netherlands, 20,000 children were measured, from

Table 9.6 Size labelling and body measurements in various countries

Country	Size label	Measurements (cm)			
		Bust	Hips	Height	Waist
Australia	14	90	95	160–170	70
Bulgaria	81	92	96	164	69.9
Czechoslovakia	3AA45	90	98	166	68
Finland	NC40 or C38	92	98	161–166	70
Germany	40	92	98	164	72.5
Hungary	164/80/94	90	94	164	68
Ireland	12	–	91–95	158–168	–
Israel	40	92	100	165–167.5	70.5
New Zealand	14	92	97	157–165	72
Poland	164/92/96	92	96	164	–
South Africa	92/96/164	92	96	165	72
Spain	42 + 2/L	92	96	167	67
Sweden	C40	90	98	163–170	–
UK	14, 38, or 8	90–94	95–99	160–170	–
USA	12 or 14	93	98	165	70
USSR	164/92/96	92	96	164	–
Yugoslavia	40	92	100	162	72

Source: Winks, 1997.[38]

which it emerged that children's height and age no longer appeared to increase in step with one another. That is why the Dutch clothing sizing system for children is no longer based on age, but on height. In the new sizing tables for children, there are 24 height categories, from 50 to 194 cm, each spaced at 6 cm intervals.[15]

In the 1970s and 1980s, ISO developed a new size labelling system in which body measurements of key dimensions are listed. Many countries revised their sizing systems by adopting the system developed by the ISO. Standard size-labelling systems were developed in the UK in 1982, in Hungary in 1986 and in South Korea in 1990. They suggested describing garment sizes in a sequence of numbers, a table form, or a 'pictogram' in which an illustration of key dimensions is drawn. These size-labelling systems will let consumers select their garments size by comparing their measured body size with the body size labelled on a garment. It is expected that consumers will find their correct garment sizes a lot easier, without having to try on too many garments, even though each manufacturer continues to have its own body measurements for each size code.[38]

9.7 Conclusion

Definitions of human anthropometrics and related terms have varied from country to country and from time to time. This chapter provides a review of

Table 9.7 Comparison of size interval and drop value of men in different countries

Germany									
Size	44	46	48	50	52	54	56	58	
Body height (cm)	168	171	174	177	180	182	184	186	
Chest measurement (cm)	88	92	96	100	104	108	112	116	
Waist measurement (cm)	76	80	84	88	92	98	102	108	
Drop (cm)	−12	−12	−12	−12	−12	−10	−10	−8	
Swiss Fashion									
Size	88	92	96	100	104	108	112	116	120
Body height (cm)	176	176	176	176	176	176	176	176	176
Chest measurement (cm)	88	92	96	100	104	108	112	116	120
Waist measurement (cm)	73	78	83	88	93	98	103	108	113
Drop (cm)	−15	−14	−13	−12	−11	−10	−9	−8	−7
France									
Size	44−38	46−40	48−42	50−44	52−47	54−50	56−52		
Body height (cm)	174	174	174	174	174	174	174		
Chest measurement (cm)	88	92	96	100	104	108	112		
Waist measurement (cm)	76	80	84	88	94	100	104		
Drop (cm)	−12	−12	−12	−12	−10	−8	−8		
Great Britain									
Size	34	36	38	40	42	44	46	48	50
Body height (cm)	174	174	174	174	174	174	174	174	174
Chest measurement (cm)	88	92	96	100	104	108	112	116	120
Waist measurement (cm)	74	78	82	86	90	98	102	106	110
Drop (cm)	−14	−14	−14	−14	−14	−10	−10	−10	−10
Netherlands									
Size	44	46	48	50	52	54	56	58	60
Body height (cm)	182	182	182	182	182	182	182	182	182
Chest measurement (cm)	88	92	96	100	104	108	112	116	120

Table 9.7 Continued

Waist measurement (cm)	75	80	85	90	95	100	105	110	115
Drop (cm)	−13	−12	−11	−10	−9	−8	−7	−6	−5
Scandinavia									
Size	C44	C46	C48	C50	C52	C54	C56	C58	
Body height (cm)	176	176	176	176	176	176	176	176	
Chest measurement (cm)	88	92	96	100	104	108	112	116	
Waist measurement (cm)	73	78	83	88	93	98	103	108	
Drop (cm)	−15	−14	−13	−12	−11	−10	−9	−8	
USA									
Size	S/34	S/36	M/38	M/40	L/42	L/44	XL/46	XL/48	
Body height (cm)	178	178	178	178	178	178	178	178	
Chest measurement (cm)	86	91	96	102	107	112	117	122	
Waist measurement (cm)	71	76	81	86	91	97	102	107	
Drop (cm)	−15	−15	−15	−15	−15	−15	−15	−15	
China									
Size	170/88A	108/92A	170/96A	170/100A	170/104A				
Body height (cm)	170	170	170	170	170				
Chest measurement (cm)	88	92	96	100	104				
Waist measurement (cm)	74	78	82	86	90				
Drop (cm)	−14	−14	−14	−14	−14				
Japan									
Size	88A5	92A5	96A5	100A5					
Body height (cm)	170	170	170	170					
Chest measurement (cm)	88	92	96	100					
Waist measurement (cm)	76	80	84	88					
Drop (cm)	−12	−12	−12	−12					

Source: Maier 2000.[40] By courtesy of Professor Angela Maier (Mrs), Dean of the Textile Department of the University of Applied Sciences, Reutlingen, Germany. Printed first by *Knitting Technology*, 22(1), p. 32.

various methods of body measuring and sizing systems. The traditional manual methods have been commonly used for many years but have many limitations. With the rapid growth of 3D body scanning technologies, many clothing researchers in several countries have initiated the need to update the national size standards which were developed in the 1940s and 1950s. The various large-scale sizing projects have been summarised in a chronological list, and the most recent national size surveys described in detail. However, the standardisation of sizing systems has been debated for a long time, and the acceptance of such a standard is sometimes in question. Even so, the principles of sizing systems, such as figure types, key dimensions, size intervals and size labelling can be drawn up as a reference for clothing education and research.

9.8 References

1. Kunick P, *Modern Sizing and Pattern Making for Women's and Children's Garments: A Scientific Study in Pattern Construction and a Standard Textbook for the Clothing Industry*, London, Philip Kunick Publications, 1984.
2. Pheasant S, *Bodyspace Anthropometry Ergonomics and Design*, London, Taylor & Francis, 1986.
3. Gray H, *Anatomy of the Human Body*, Lea and Febiger, Philadelphia, 1918.
4. Kemsley R, *Women's Measurements and Size – A Study Sponsored by the Joint Clothing Council Limited*, London, HMSO, 1957.
5. Beazley A, 'Size and fit: procedures in undertaking a survey of body measurements', *J Fashion Marketing and Management*, 1997 **2**(1) 55–85.
6. Lohman T G, Roche A F and Martorell R, *Anthropometric Standardization Reference Manual*, Human Kinetics Books, Illinois, 1998.
7. Kouchi M and Mochimaru M, *Japanese Body Dimensions Data 1997–1998*, English version, Digital Human Laboratory, National Institute of Advanced Industrial Science and Technology, 2002.
8. Cameron N, *The Measurement of Human Growth*, Sydney, Croom Helm, 1984.
9. Devarajan P, Istook C L and Simmons K P, 'U.S. sizing standards and the U.S. female consumer', *Proc of IFFTI Conf, Fashion and Text: the New Frontiers – Design, Technology and Business*, Hong Kong, 7–9 Nov., 2002.
10. Armstrong H J, *Patternmaking for Fashion Design*, New York, Prentice Hall, 2000.
11. Swearingen E, *Theoretical Model for Apparel Design Curriculum: Fit Satisfaction, Body Cathexis and Creativity*, MSc Thesis, California State University, Fresno, 1999.
12. National Bureau of Standards Commercial Standard CS215-58, *Body Measurements for the Sizing of Women's Patterns and Apparel*, Washington, D.C., U.S. Department of Commerce, U.S. Government Printing Office, 1958.
13. National Bureau of Standards Commercial Standard PS42-70, *Body Measurements for the Sizing of Women's Patterns and Apparel*, Washington, D.C., U.S. Department of Commerce, U.S. Government Printing Office, 1970.
14. French G E, 'International sizing', *Cloth Inst J*, 1975 **23**, 155–162.
15. TNO magazine, 'New clothes sizing charts: fitting selection offered to the consumer', URL: http://www.tno.nl/en/news/tno_magazine/march_2002/

em1_12_13.html, 2002.
16. KS K0068, *Sizes for Women's Blouse*, Seoul, Korean Industrial Standard Association, 1981.
17. Chun-Yoon J and Jasper C R, 'Garment sizing systems – an International comparison', *Int J Cloth Sci Technol* 1993 **5**(5) 28–37.
18. Gordon C C, Bradtmiller B, Clausner C E, McConville J T, Tebetts I and Walker R A, 'Anthropometric survey of US army personnel', *Technical Rep NATICK/TR-89/044*, Natick, MA, US Army Natick Research, Development, and Engineering Center, 1988.
19. Ashdown S P, 'An investigation of the structure of sizing systems – a comparison of three multidimensional optimized sizing systems generated from anthropometric data with the ASTM standard D5585–94', *Int J Cloth Sci Technol*, 1998 **10**(5) 324–341.
20. KS K0051, *Sizing System for Women's and Girl's Garment*, Seoul, Korea Standard Association, 1990.
21. National Institute of Bioscience and Human Technology, *Japanese Body Size Data 1992–1994*, Osaka, National Institute of Bioscience and Human-Technology, 1997.
22. Goldsberry E, Shim S and Reich N, 'Women 55 years and older: Part I. current body measurements as contrasted to the PS 42–70 data', *Cloth Text Res J*, 1996 **14**(2), 108–120.
23. Bougourd J P and Treleaven P C, 'Capturing the shape of a nation: Size UK', *IFFTI Int Conf*, Hong Kong, 2002.
24. Fashion Business International, 'US launches national sizing survey', *Fashion Business Int*, 2002 (June/July) **32**.
25. Workman J E, 'Body measurement specification for fit models as a factor in apparel size variation', *Cloth Text Res J*, 1991 **10**(1) 31–36.
26. LaBat K L and Delong M R, 'Body cathexis and satisfaction with fit of apparel', *Cloth Text Res J*, 1990 **8**(2) (Winter) 42–48.
27. Kouchi M, 'Secular change and socioeconomic difference in height in Japan', *Anthropological Sci*, 1996 **104** 325–340.
28. Robinette K, Blackwell S, Daanen H, Fleming, Boehmer M, Brill T, Hoeferlin D, and Burnsides D, 'Civilian American and European Surface Anthropometry Resource (CAESAR)', *Final Rep, 2002 Volume I: Summary, AFRL-HE-WP-TR-2002-0169*, United States Air Force Research Laboratory, Human Effectiveness Directorate, Crew System Interface Division, 2255 H Street, Wright-Patterson AFB OH 45433-7022.
29. Nedscan, URL: www.nedscan.nl, 2001.
30. Size USA ([Online]), 'Let's Size up America', URL: http://www.sizeusa.com.
31. TC^2, 'Size USA Moves to the West Coast', URL: http://www.tc2.com/RD/RDNews.htm, 2003.
32. MacDuff L and Smith J R, ([Online]) 'African Body Dimensions – A South African Anthropometric Initiative', URL: http://cyberg.wits.ac.za/cyberg/sessiondocs/physical/anthro/anthro4/anthro4.htm.
33. Dunne N, *Understanding the South African Clothing Manufacturing Sector' from the Perspective of Leading South African Clothing Retailers*, Industrial Restructuring Project, School of Development Studies, University of Natal, Research Report No. 31, 2000.
34. Human Science Research and Development, Brochure of Wacoal (Shanghai) Human

Science R&D Co Ltd 2003.
35. Program & Event, *IFFTI International Conference, Fashion and Textiles: the New Frontiers – Design, Technology and Business*, 7–9 Nov., 2002, Hong Kong, 2002 p. 6.
36. Zhang W Y, Li K & Dai W, 'Analysis of Chinese female body shape', Keynote Speech, *IFFTI Int Conf Fashion and Text: the New Frontiers – Design, Technology and Business*, 7–9 Nov., 2002, Hong Kong, 2002.
37. Sohn H S, Lim S, Kim H S, Son H J, Kim Y S, Jang H K & Jung R, *A study on the comparison of body types between Chinese and Korean college women*, Costume Culture Assoc, Korean, 1999 2(1) 43–53.
38. Winks J, *Clothing Sizes – International Standardization*, Manchester, The Textile Institute, 1997.
39. ISO 8559 *Garment Construction and Anthropoetric Surveys – Body Dimensions*, International Organization for Standardization, 1989.
40. Maier A, 'International size chart comparison for men', *Knitting Technol*, 2000 **22**(1) 32–36.
41. Wicks J, 'Mondoform – the breakthrough in the sizing of apparel', *Apparel Int*, 1991 32.
42. Simeon B, 'Berlei size right survey', *British Clothing Manufacturer*, 1973 **9**(4) 32.
43. Bougourd J P, Dekker L, Ross P G and Ward J P, 'A comparison of women's sizing by 3-D electronic scanning and traditional anthropometry', *J Text Inst*, 2000 **91**(2), 163–173.
44. LaBat K L, *Consumer Satisfaction/Dissatisfaction with the Fit of Ready-to-wear Clothing*, University of Minnesota St Paul, 1987.
45. Desmarteau K 'Let the fit revolution begin', URL: www.findarticles.com, 2000.
46. Senanayake M M and Little T J, '''Measures'' for a new product development', *J Text Apparel Technol Management*, 2001 **1**(3) 1–10.
47. Snyder R G, Scheider L W and Owings C L, 'Infant, child and teenager anthropometry for product safety design' *Advances in Consumer Res*, 1978 **5**.
48. Chun-yoon J and Jasper C R, 'Consumer preferences for size description systems of men's and women's apparel', *J Consumer Affairs*, 1995 **29**(2) 429–441.
49. Kuma M, *The Development of a Design Guide for the Plus-size Body-form*, MSc Thesis, Technikon, Pretoria, 1999.
50. DOB-Verband *DOB-Grossentabellen (Women's Outer Garment Size Chart)*, Germany, Cologne, 1983.
51. MSZ 6100/1-86, The Office of Hungarian Standards, Budapest, Hungarian People's Republic State Standards, 1986.
52. National Bureaus of Standards CS 215-58, *Body Measurements for the Sizing of Women's Patterns and Apparel*, Washington DC, U.S. Department of Commerce, N. B. O. S. N., US Government Printing Office, 1958.
53. McConville J T, Tebbetts I and Churchill T, 'Analysis of body size measurements for US navy women's clothing and pattern design', *Naval-Cloth Text Res Facility*, 1979.