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International Anthropometric Data

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International Anthropometric Data for Work-Place and Machinary Design

Contents

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Internationaler anthropometrischer Datenatlas

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Human Body Measures – Dynamic Body Measures

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1 Introduction

A main prerequisite for the design of work-places and machinery coming into direct contact with human beings are human body measures. These cannot refer to single averages of standard values but must take the variability of the intended user population into account. In order to design a humane environment, data on average body height is not sufficient. Taking into account the differing variation of measurements which show only low correlation with body height, it is necessary to assess a number of body measures separately in their specific variation.

Such research has been performed in Europe on a national basis, yet often only for a small range of occupations. The increasing economic integration of the European countries that has lead to joint regulations in the areas of working place design and safety now requires the availability of data assessing "the Europeans" and their needs. The importance of body measures for working life is the reason for yielding the measures in question for the group between 18 and 60 years of age at this point.

2 Variation of body measures

It is common knowledge that the body measures of human beings and the average dimensions of populations show characteristic variations.

2.1 Prelimery Stage

Age is an important aspect in this respect. Body measures of adult human beings change in the course of life: measures of length sometimes decrease, circumferences and measures of width increase, and the phenomenon of acceleration, which has been acting upon human beings for centuries, has led to the circumstance that younger persons have longer body measures than older ones.

Sex differences are a further factor. On average, women's body height is 10 cm lower than men's in the European population. In addition, women have a slightly higher amount of body fat and a lower one of muscle tissue, which has an effect upon single body measures. Proportional differences also occur, such as the ratio of torso and extremities and slightly higher pelvis measures etc.

A third important point for the variation of body measures is the regional differentiation in Europe. As a general rule, the Northern Europeans show higher measures than Southern Europeans. The anthropological expression of sexual dimorphism also exhibits regional differentiation: it is expressed to a higher degree in Southern than in Northern Europe.

2.2 Structuring of the variations

How can the wealth of data and its variation be structured in order to obtain applicable results in practice? A simple and somewhat naive attempt is simply to calculate averages. However, if these values are applied in practice, for instance in calculating the height of a passage according to the average body height, half of the population will bump into the ceiling. If the sitting surface height of a chair is determined according to the average lower leg length

of a population, half of it will not reach the floor with their feet. Both examples show that the dimensions of the "average person" are unsuitable and that it is necessary to account for the existing variation in other ways.

Another possibility would be to use the largest and the smallest human being of a population as upper and lower limit. In this case, such extremes would be reached in the metric dimensioning of environments that the majority of the population would be impeded in their quality of life and safety of work.

The percentilization of measurements has been introduced as an aid: a percentiled value expresses how many individuals of a specific population exceed this value in either direction for a specific measurement. For example, for German adult males, the 5^{th} percentile body height (P5) amounts to 167 cm. This means that 5 % of all adult male Germans are smaller than this measure, and 95 % are taller. In ergonomic practice, the 5th and the 95^{th} percentile have become established as limits. This means that in the respective measures, 5 % with the lowest and the highest dimensions in the adult population are not accounted for. This agreement is based upon extensive practical experience on international basis. In the area of safety at working places, the thresholds are extended to encompass the first to the 99^{th} percentile, so that only 2 % of the population, the smallest and the tallest, are excluded to a certain degree.

In practice, the "average person" does not play an important role today, while percentiled data is the information that is sought after. In this context, it is important to mention that it is not possible to construct an individual's body measures from the knowledge of body height only; as a matter of fact every human being has a sometimes considerable variability within his own body, for instance a man of the 50^{th} percentile body height can belong to the 80^{th} percentile concerning his foot length.

2.3 Application in the practice

The constructor, architect or designer who is confronted with percentiled values of different body measures in a population, is faced with the problem how to construct his product metrically, be it a working place, a machine or a consumer product.

There are various possibilities:
Products in different sizes: The textile industry, the shoe industry and other fields, for instance school furniture production, offer products in a variety of sizes. These sizes do not refer to a single dimension but to specific measurement combinations which occur frequently in the population.

Adjustment: A very frequently used solution in adapting products to the human body is adjustment. For instance, many seats allow for an adjustment of the sitting surface, the back rest and, in vehicles, the distance to the controls. In this way, the variability not only of a certain measurement, but instead of various combinations as "tall sitters" or "small sitters" (esp. high or low sitting height) can be accounted for.

Determination of the "critical measurement": In some areas, it is neither possible to make use of varying sizes nor adjustment. In such cases, the

"critical measurement" needs to be determined, for instance concerning doors or other passageways, the critical measurement will be based on the highest percentiles of body height in a given population. In designing sitting areas, where it is important that the user be able to at least reach the floor with his feet, the lowest leg length percentiles will determine the critical measurement since persons with longer legs can stretch them out. In determining the critical measure, the "average person" can again play a role, for instance in establishing the height of sales desks.

Minorities: Sometimes the question arises how persons who exceed the percentiles 5 or 95 in some or all body measures are taken into consideration. Since industrial series production of goods is only sensible for supplying a metrically limited range of measures, it is necessary to find special solutions for minorities. Telephone booths offer a good example: Again and again wheelchair users complain that the telephones in standard booths are fastened too high for them to operate, at the same time associations of tall persons are complaining that the ceiling height is too low in all booths. An exemplary solution would be the use of a new concept, for instance supplying mobile telephones. For economical and ecological reasons, it is not useful to extend the adjustment mechanisms in cars so far as to allow for the usability by the most short and long-legged persons. The result would be that 90 % of the population would have to pay for and transport the resulting size enlargements and the additional weight without being able to make use of them at all.

3 Definition of the average European

Taking the European Community as an economical unit with all resulting consequences for the job market and product design, the suggestion to take into account the entire adult population of Europe in percentilization would be only too natural. However, this seemingly logical solution has severe drawbacks concerning the limiting percentiles 5 and 95: In the anthropometrically comparatively extreme areas of Europe, in the north, where individuals are taller, as well as in the south, where individuals are smaller, the population density is much lower than in central Europe. Therefore, an all-European calculation of the common averages out of all national values of the respective percentiles could lead to the fact that, for instance in Norway, a high percentage of all men would exceed the European P95 values, while most women in Portugal or Greece would be excluded by the P5 values. In this way, the smaller states, which are farthest from the geographical center of Europe, would be severely disfavored. Therefore, an all-European solution was abandoned in defining the anthropometrical European.

A compromise concerning a differentiated solution was found in defining the median (P50) of all measures of the European population by way of the all-European calculation, while the limiting percentiles P5 and P95 were to be set according to the countries hosting the highest and the lowest body measures in their population respectively. In order to avoid too small splinter groups, 3 million individuals were defined as threshold of a population to be taken into account. In order to avoid a too extreme "straddling" of the limiting percentiles, it was agreed that the "extreme" countries would fix the upper and the lower percentiles respectively, but that they would not be differentiated according to sex, but rather averaged between women's and men's values.

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As a consequence of this compromise, the widened range of the limiting percentiles covers a higher amount of population groups despite unchanged medians of the European. Further, the traditional differentiation according to sex is abandoned in favor of "human percentiles".

4 Data basis

4.1 Definition of Measures

One of the main prerequisites for a practical applicability of anthropometrical measures is their clear description. If it is necessary for working place design to use the eye height of a sitting individual, it is essential to know how this was measured. Did the test subjects sit with supported backs or upright, did they maximally stretch their spine or sit in a relaxed, slack position? The necessity for clear, reconstructible definitions of body measures has been accepted for a long time. Based upon long-lasting international agreements, a standard was developed in the context of European standardization providing a basis for this (DIN EN ISO 7250: Important measures of the human body for technical design). The definitions given in this standard form the basis of the body measures compiled in this report.

4.2 Available data

It is planned to perform representative anthropometrical surveys for the populations of the different European countries based upon the defining standard DIN EN ISO 7250. Since the collection of data will be performed according to one and the same sample definition, the data will be comparable methodologically, and it will yield useful information about the anthropometry of "the European". However, it is to be expected that usable data will only be available in several years because of the technical and economical expense of such an undertaking. For this reason, in order to meet the many requirements of working life in practice, it is sensible at this point to compile, supplement and standardize the data that has been collected in many European countries, so that comparable anthropometric references are available as an intermediary solution.

The availability of anthropometric data varies to a large degree in the different European countries. Some countries have been anthropometrically assessed to a large extent, others only show a very limited survey. Also, the different definitions used in measuring and the population groups assessed need to be taken into consideration. Often, examinations are performed with persons from the armed forces, from sports or from the student body of universities; therefore it is necessary to evaluate their representativeness for the whole population, for example concerning the age composition of the sample. Another factor of influence to be respected is the differing intensity of the process of secular acceleration in the various countries, which has acted upon different population groups to different degrees in the course of this century. This enhances the influence of another demographic factor: populations with a high percentage of young persons show a higher body height because of the acceleration process than populations with a higher percentage of older individuals.

This factor is to be respected in compiling and standardizing available data insofar as older surveys do not represent the current population metrically because of the continuing process of acceleration.

4.3 Data processing

The unstandardized nature of the available data necessitates a thorough examination of the single surveys concerning the factors of influence and conditions listed above. After that, missing data needs to be supplemented on the basis of the available data respecting age and sex differences in their proportions. In doing this, the lacking correlation resulting from group specific variation needs to be taken into account. It is not possible to deduce other measures from body height alone, since the correlation between the different types of measure vary to a large extent: while most measures of length show a high positive correlation, measures of breadth, depth and circumference as well as measures of the hand, foot and head show a relatively small biometrical relationship to the measures of length of the human body.

For the following compilation of European data, a favorable matter is the anthropometrically central position of the group for which the most recent representative evaluations are at hand, this being the German population. This extensive material will allow for the necessary interpolation of measures of other populations.

5 Body measures of the average European

Measures will be given as averaged values for both sexes in the age group between 18 and 60 in the percentiles 5,50 and 95 (defined in part 3).

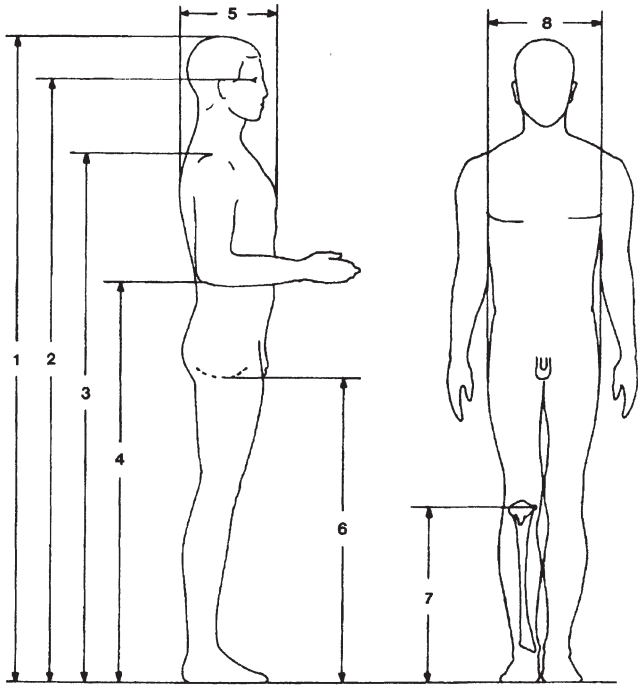
Measures were taken according to the definitions of DIN EN ISO 7250, meaning in maximally upright position.

Values (in mm) refer to the naked body, where necessary, extra space needs to be taken account of for shoes and clothing in using the data.

Further additions or subtractions need to be respected in the construction of working places, machines and equipment, for instance accounting for wearing of personal protective gear, movements of the body or relaxed sitting. It can be referred to the extensive literature on this topic (i.e. Schriftenreihe der Bundesanstalt für Arbeitsschutz und Arbeitsmedizin – Forschung –, "Handbuch der Ergonomie", and Schriftenreihe "Ergonomische Studien" of the Bundesamt für Wehrtechnik und Beschaffung (BWB)).

Body measures of the average European

No. (see fig.)	Description of Measurement	Percentile		
		5	50	95
1	stature (body height)	1530	1719	1880
2	eye height	1420	1603	1750
3	shoulder height	1260	1424	1570
4	elbow height	960	1078	1190
5	chest depth (meso-sternal level)	170	215	250
6	crotch height (equivalent to the tailor's measurement "inside leg")	709	816	890
7	tibiale height	397	472	530
8	hip breadth	300	359	400



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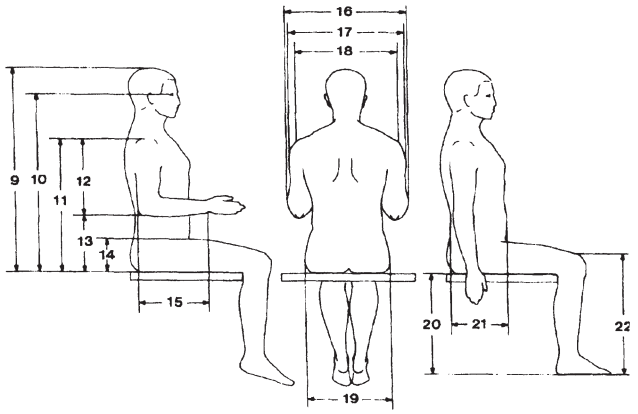
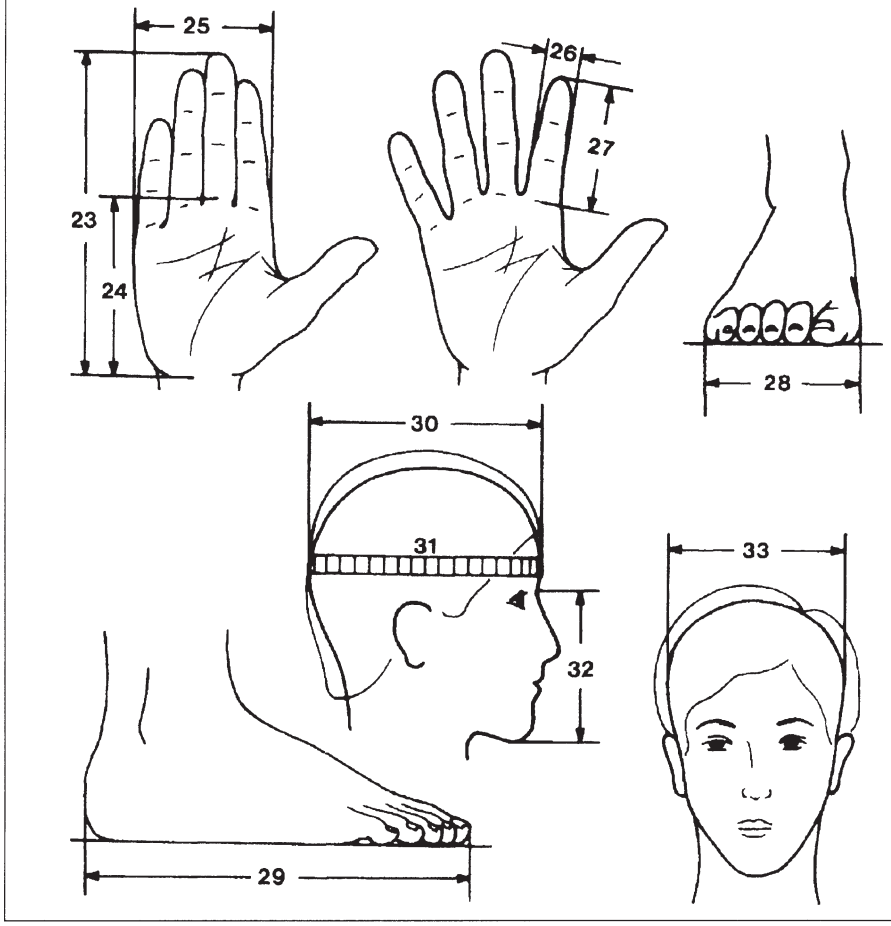
Body measures of the average European

No. (see fig.)	Description of Measurement	Percentile		
		5	50	95
9	sitting height	790	905	985
10	eye height	680	790	860
11	shoulder height	510	623	695
12	shoulder-elbow length	288	346	410
13	elbow height	190	243	280
14	thigh clearance	112	146	170
15	elbow-wrist length	240	279	318
16	elbow to elbow breadth	390	478	540
17	shoulder breadth, bi-deltoid	395	474	485
18	shoulder breadth, bi-acromial	320	380	425
19	hip breadth	333	368	440
20	lower leg length (popliteal height)	380	444	495
21	abdominal depth	195	237	350
22	knee height	460	530	602



Body measures of the average European

No. (see fig.)	Description of Measurement	Percentile		
		5	50	95
23	hand length	164	182	202
24	palm length	94	107	119
25	hand breadth	72	81	92
26	index finger breadth, proximal	16	20	24
27	index finger length	64	73	80
28	foot breadth	84	96	110
29	foot length	232	255	280
30	head length	176	192	207
31	head circumference	526	560	594
32	face length	99	112	127
33	head breadth	138	149	158



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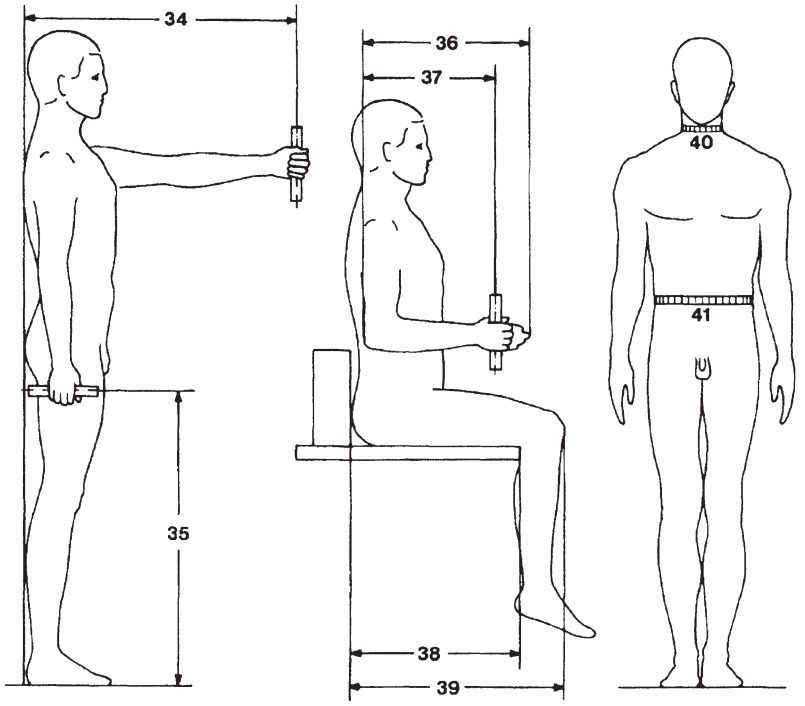
Body measures of the average European

No. (see fig.)	Description of Measurement	Percentile		
		5	50	95
34	forward reach (grip axis)	640	728	820
35	fist height (grip axis)	660	764	845
36	forearm fingertip length	410	457	498
37	elbow-grip length	298	338	403
38	seat depth (body depth, sitting)	430	499	560
39	buttock-knee length	543	604	664
40	neck circumference	301	346	394
41	waist circumference	680	741	940



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