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Croatian Anthropometric System

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Abstract: Abstract: Anthropometry as part of anthropology methods is the study of the measurement of the human body in terms of the dimensions of individual human body parts. Under present conditions of manufacturing fashion garments the significance of the size system is of paramount importance. In order to meet the demands of an increasing number of customers, it is important to develop and advance such systems which will enable the selection of garment sizes applicable in individual and group preferences. Anthropometric measurements of the national population represent the fundamental basis for garment size systems. Anthropometric measurements started to gain importance from 1901 when the US Government established the National Bureau of Standards (NBS) with the mission of advancing measurement standardization for science and industry. Afterwards many countries conducted comprehensive anthropometric measurements in order to advance garment size systems. Over the period from 2004 to 2006 the first comprehensive anthropometric measurement on the sample of 30,866 subjects from birth up to people aged 82 years was made in 20 Croatian counties and in the city of Zagreb. During the realization of this complex scientific research project "Croatian Anthropometric Project" two patents were generated. In this way a basis for new Croatian garment size standards was established. The paper describes problems and necessity of standardization. The field investigations lasted for 17 months in which 109 trained field measurers took part. The paper also describes anthropometric properties, measurement procedures and implementation strategy. Based on the statistical analysis of data of anthropometric measurements an overview of the results of body measurements according to age groups and sex is presented. The results of the newest anthropometric measurement are of outstanding significance for many scientific fields and disciplines, and also for comparison with other national measurements in Europe and worldwide.

1. INTRODUCTION

Under present conditions the need for developing a size system is emphasized since in this manner it is possible to make a selection of garment and footwear sizes for individual and group demands. To make garment cuts, it is necessary to study a large number of proportions. By proportions or relationships it is possible to find a proper interrelationship between individual body parts and individual measurements respectively so that body deviations form average body composition, i.e. from its deformation.

Measurements obtained by anthropometric measurements of the representative sample of a specific population are used in designing and modelling in the clothing and footwear production. To meet the requirements of the market, it is necessary to ensure appropriate garment size systems so that an averagely developed person could find his/her clothing size. The compound technological project (STIRP) CAS should ensure new size systems serving as a guide to Europe since the developed countries improve their standards each 15 to 20 years on average.

In the realization of the above-mentioned project a team of about 25 experts from different scientific fields or specialists for the field of construction, technology, statistics, mathematics, philosophy, anthropology, occupational medicine and paediatrics. The Faculty of Textile Technology, University of Zagreb, was in charge of the project together with the following institutes: Institute for Anthropological Research and School of Public Health "Andrija Štampar", Faculty of Medicine of the University of Zagreb. In addition to these institutions, experts of the Faculty of Philosophy of the University of Osijek, the Faculty of Medicine of the University of Split and Faculty of Economics and Business of the University of Zagreb took part in the project. Several consultants from the clothing and footwear industry participated too and technical staff [1, 2].

The results of the national anthropometric measurement of a sample of 30,866 subjects are applied as the scientific-professional basis for a new garment and footwear size system in the Republic of Croatia.

The first method for anthropometric measurements was published in the USA, including 10,042 women in order to

obtain a women's apparel size system. In 1901 the US Government established the National Bureau of Standards (NBS), a non-regulatory agency, with the mission of advancing measurement standardization for science and industry. In 1921 the first report on the American anthropometric survey was published. It contained the determination of clothing sizes on about 100,000 men during the demobilization at the end of the First World War. Over the period from 1937 to 1941 the American size survey was published, and it was conducted on about 147,000 boys and girls all over the country [3].

2. ANTHROPOMETRIC CHARACTERISTICS

Anthropometry is used in considering many theoretical and applied topics in anthropology, such as changes in body size and shape related to life cycle, evolution and microevolution, issue of a relative contribution of genetic and environmental factors to body morphology under various life conditions, issue of the relationship between body morphology and body capability, diseases etc.

Anthropometry requires well defined procedures to obtain homogenous, accurate and reliable data that can be compared with different populations. These anthropometric instruments and methods of measuring are standardized, and a standard set of anthropometric variables has been established. In addition to monitoring changes in body morphology occurring during growth, anthropometry makes it possible to recognize changes occurring gradually in successive generations.

Within the framework of investigating the morphological variability of human beings great interest originates for anthropometric indicators showing how well nourished world populations are as well as in all life periods. Results obtained by anthropometric measurements are compared with referent values by means of which "normality" is assessed and its deviation. Based on the results of a series of population studies it may be concluded that anthropometric characteristics of present populations reveal a geographic variability reflecting migration movements, epidemic influences and different social events in history [4, 5].

2.1. Review of the first national anthropometric measurement of the population of the Republic of Croatia

In 1963 an experimental anthropometric measurement of the population was made the autonomous province of Vojvodina, conducted by the Institute for the promotion of the organization of industrial production and labor productivity in Novi Sad. The measurement included 5,000 subjects of both sexes, aged from 2 to 55 years, divided into 2 age groups aged from 2 to 19 years and from 20 to 55 years. This is a very small sample. Therefore, there was need for own garment size system in Croatia, and not just to convert the Yugoslav Standard known as JUS into the Croatian standard HRN. In the field work of the project 109 measurers and 15 record-keepers took part. For the needs of STIRP CAS the standard method was applied that is in use for similar projects in Europe and in the world [6, 7, 8]. The following was used:

- a set of anthropometric instruments (one-arm and/or two-arm anthropometers,
- measuring tapes,
- a specially designed protractor,
- a sliding anthropometer and
- digital scales.

For the purposes of this project the one-arm and/or two arm anthropometer was considerably improved (D. Ujević: Patent application) and a specially designed protractor (G. Nikolić and D. Ujević: Patent) [9].

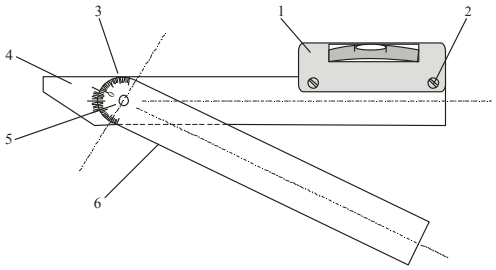

Fig. 2.1 One-sided protractor for measuring the angle of the shoulder slope

Fig. 2.1 shows a one-sided protractor consisting of:
1. Water-level
2. Fixing screw
3. Degree markings notched onto the edge
4. Horizontal ruler
5. Coupling rivet
6. Arm or hinged ruler

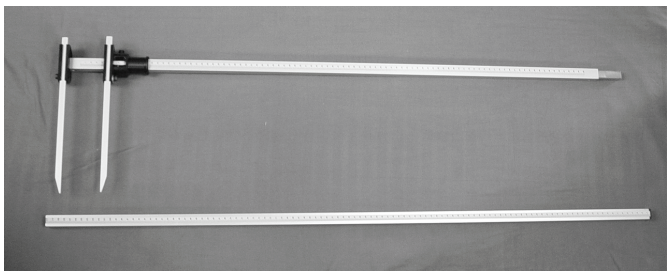

Fig. 2.2 One-arm anthropometer and/or two-arm anthropometer

Fig. 2.2 shows the two-arm anthropometer adjusted to the requirements of this project. It consists of two parts.

Before taking anthropometric measurements it is essential to determine the accurate position of individual anthropometric points on the human body. They are divided into fixed and virtual ones.

The measurement included two groups of children, specifically until the age of 5.4 years for whom 15 measurements were determined, and there is no difference in the measurements between the sexes. For older children until the age of 10 years 30 measurements were determined with a

difference between the sexes. For children older than 10 years the measurement was taken in the same manner as for the adults of the male and female sex respectively (54 measurements in men and 57 measurements in women) [10].

2.2. Measurement organization

The success of the field work of anthropometric measurements depends mostly on the methods for measurement organization, organization of the measuring place and skills of the measurement team. During the measurement organization in a specific sector it was necessary to prepare the organization with the following assignments:

• In its sector it should systematically organize the collaboration with work organizations, institutes, institutions and other structures in which there are potential subjects who will be subjected to anthropometric measurements.
• The public should be informed by the press, printed information and invitations, by using e-mail, Internet, radio and TV in order to find subjects.
• Finding, inviting, informing as well as editing lists of subjects (or groups) according to the sex and age groups with an approximate time schedule of their measurements.
• Organization and equipment of measuring places and complete space to measure subjects being subjected to anthropometric measurements.
• Establishment of work measurement teams who will attend a training seminar for measurers.

The success of field investigations of anthropometric measurements depended on the level of the organization of the measuring place so that special attention was paid to the arrangement of the premises, the reception of subjects and the coordinated and skillful work of the whole measurement team [2, 11].

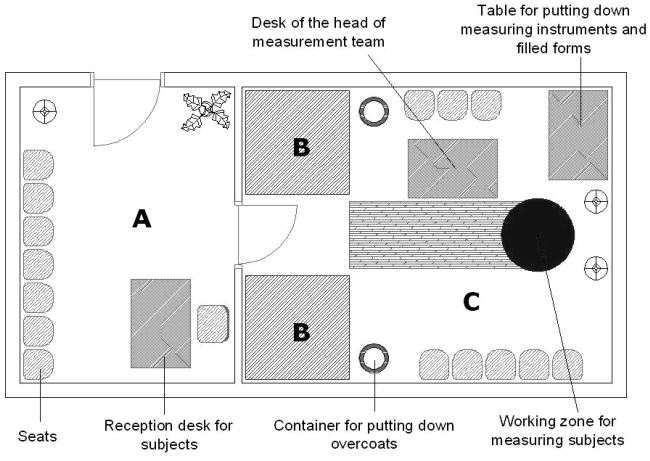

Fig. 2.3 Schematic representation of the organized workplace: a) waiting room, b) dressing room, c) measuring room

2.3 Instruments used for measurements

The following instruments were used for anthropometric measurements:

• Scales is used to weigh the mass of a body. Small portable digital scales are in use. Measurement accuracy is displayed on Liquid Crystal Display (LCD) to 0.5 kg with a measurement range up to 130 kg, and it is recommended to measure always on the same scales. After several measurements it is necessary to calibrate the scales so that the pointer always points to zero. During measuring the scales should be placed on the solid horizontal support.
• Anthropometer is a 2 m long measuring instrument with a round or angular profile. It is composed of two parts calibrated by a centimeter or millimeter scale. The movable part of the anthropometer slides along its entire length. The one-arm anthropometer measures body height, trunk sitting height, sitting height up to the head vertex, height of waist, hips and knees, crotch length, whereas the two-arm anthropometer measures trunk length, seat depth and inside upper leg length. The precision of the anthropometer scale amounts to 0.1 cm, and measurement accuracy amounts to 0.5 cm. Values are read from a quadratic opening in the midline of the opening which covers the obtained unit of measurement (Fig. 2.2).
• Sliding anthropometer is a measuring instrument with a scale range from 15 or more cm, and a reading accuracy of 0.1 cm. It is used to measure smaller distances. Values are read on the line covering the inside edge of the anthropometer arms.

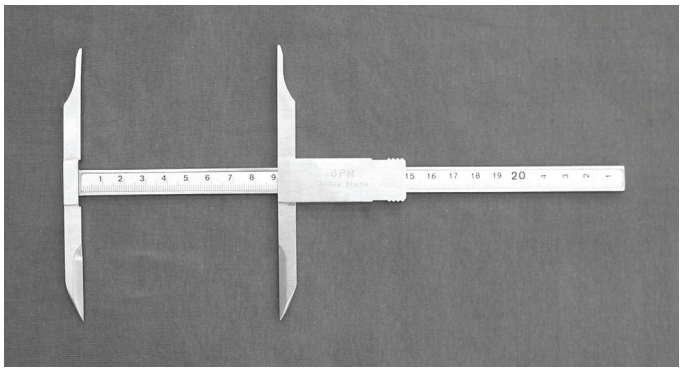

Fig. 2.4 Sliding anthropometer

• Measuring tape is a ribbon of plastic with a centimeter and millimeter scale. Its length is either 150 or 200 mm, and measurement accuracy amounts to 0.1 cm. It is self retracted into a plastic or metal container. A ribbon of cloth is unsuitable for use due to its coefficient of elasticity.

Fig. 2.5 Plastic tape measure with container

• Protractor is used to measure shoulder slope and has been constructed specially for the purposes of CAS. Measurements are taken in such a way that the instrument is placed on the shoulder and follows the line connecting the shoulder tip and the point of joining the shoulder and neck. Degree values are red when the air is between the markings (Fig. 2.1) [2, 9].

Figures 2.6 and 2.7 shows the measuring instrument (tape measure and sliding anthropometer) and some of the dimensions on a silhouette of the body of a human being obtained by using this instrument.

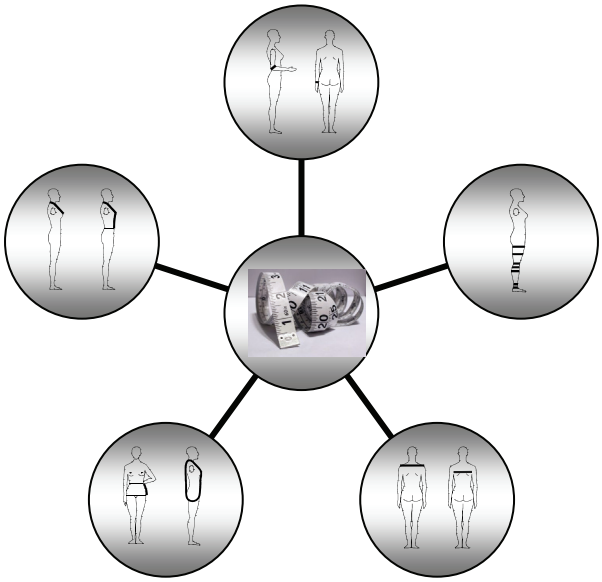

Fig. 2.6 Measurement representation using a tape measure on a silhouette of the human body

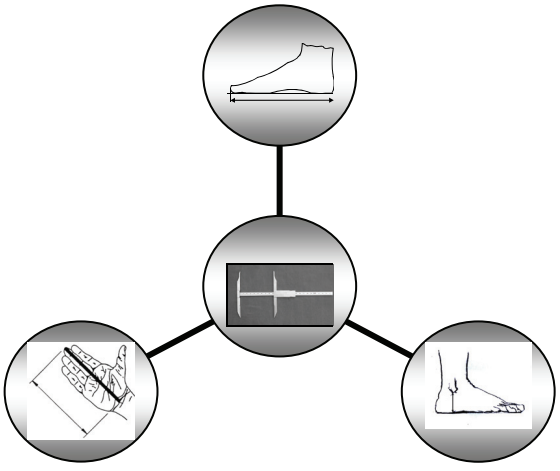

Fig. 2.7 Measurement representation using a sliding anthropometer on a silhouette of the human body

3. Strategy of the realization of STIRP CAS

A strategic approach to the realization of the project required:
• adequate selection of associates
• planning and adequate organization
• accurate division of assignments
• harmonization of the dynamics of their implementation
• interactive procedure for conducting the process of the project realization.

It is necessary to specify a basic document that proposes the aim of a particular project activity and the procedure of its realization. In conducting scientific projects the strategic approach includes connecting and harmonizing different knowledge types, specific methodologies and special professional interests of the team of scientific and professional participants [12].
There is a complete list of scientific and professional participants in the STIRP CAS together with sublists of:
1. Project council
2. Scientific and professional associates
3. Economic consultants
4. Team members of the technical staff
5. Regional organizers (county) of field investigations
6. Teams of measurers (in counties).

The initiation of the process of the project implementation included:
- gathering the technical staff for administration and logistics
- gathering scientists and professional associates for processing, analyzing and presenting the test results and gathering consultants from among future users of the test results
- finding local coordinators for the organization of field investigations
- generating interest in the public, institutions and potential users of the test results for the initiation and support in the project realization and
- animating the population for personal approach to measurements.

The necessity of a strategic approach to conducting the project is also the voluminosity of field measurements (30,866 subjects of the Republic of Croatia), but also the fact that the project gathered associates of different professions, different qualifications, scientists and consultants with different specific knowledge types who approached the problem of investigation with a different research methodology and interest for the investigation results of the morphology of the human body [12].

4. Presentation of the test results of the national measurement of the population of the Republic of Croatia
Based on the census of the population of Croatia from 2001 the number of measurements for each Croatian county and the City of Zagreb was determined shown in histogram 4.1 [13].

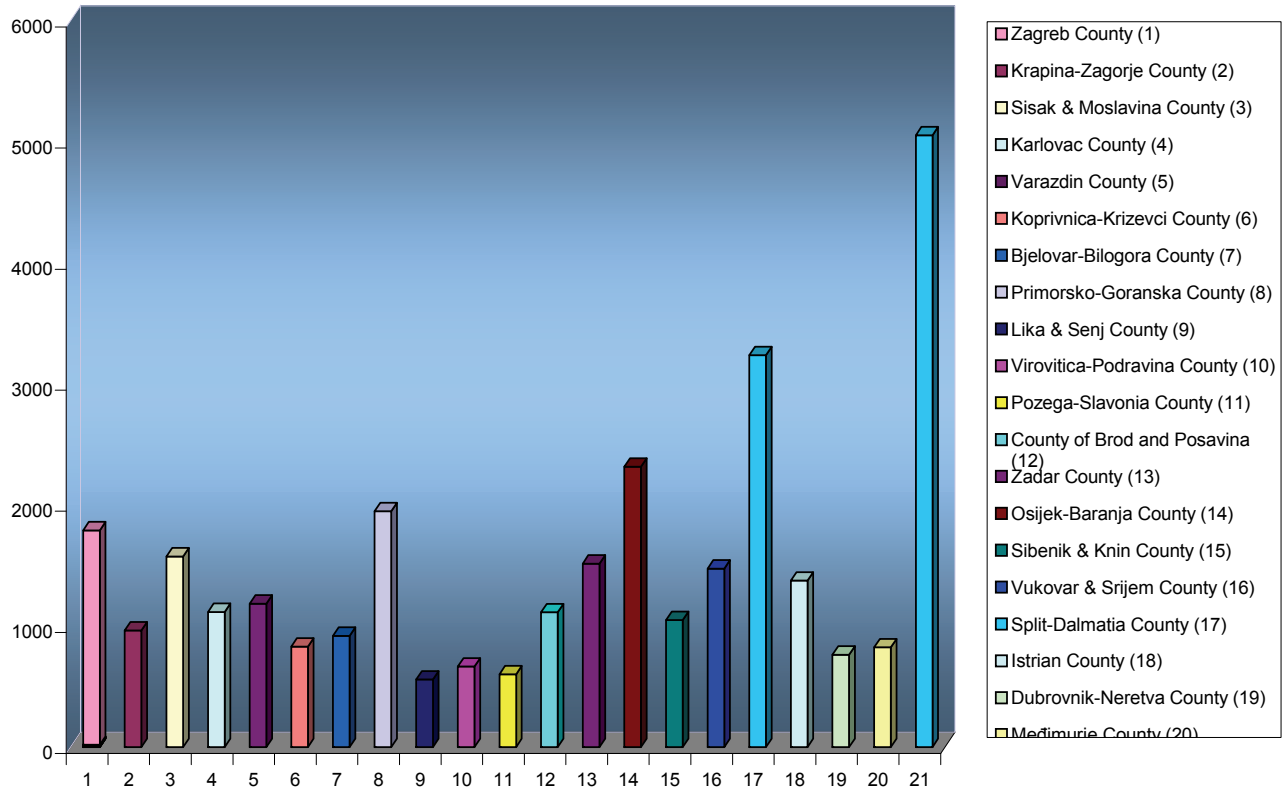

Figure 4.1: Histogram of the total number of subjects measured in 20 counties and the city of Zagreb

Based on the histogram it may be concluded that the greatest number of measurements was made in the city of Zagreb where 5,054 subjects were measured, while only 558 subjects were measured in Lika & Senj County.

The necessary number of subjects was determined in such a way that the number of inhabitants of each county was considered in relation to the total number of the inhabitants of Croatia (proportional share), taking account of the ratio of male and female subjects and their age.

For the purposes of anthropometric measurements tables of age groups were created based on morphological features tracing the dynamics of growth and development so that for the youngest age group (from birth up to 5.4 years of age) 11 age groups was determined, for the period up to the (theoretical) end of the development process (from 5.5 to 20.4 years of age) 15 age groups for girls and 15 age groups for boys and for the adults 7 age groups for men and 7 age groups for women were determined.

Table 4.1 Common age groups

No. of age group	Age		Gender
1.	0 – 3	months	(m+f)
2.	4 – 6	months	(m+f)
3.	7 – 9	months	(m+f)
4.	10-12	months	(m+f)
5.	13-15	months	(m+f)
6.	16-18	months	(m+f)
7.	19-24	months	(m+f)
8.	25-30	months	(m+f)
9.	2.5-3.4	years	(m+f)
10.	3.5-4.4	years	(m+f)
11.	4.5-5.4	years	(m+f)

A total of 55 age groups were determined with Table 4.1 showing the common age groups (no division by gender) and individual age groups in Table 4.2 [11, 14].

Table 4.2 Individual age groups

No. of age group	Age		Gender	No. of age group	Age		Gender
12.	5.5-6.4	years	(m)	**13.**	5.5-6.4	years	(f)
14.	6.5-7.4	years	(m)	**15.**	6.5-7.4	years	(f)
16.	7.5-8.4	years	(m)	**17.**	7.5-8.4	years	(f)
18.	8.5-9.4	years	(m)	**19.**	8.5-9.4	years	(f)
20.	9.5-10.4	years	(m)	**21.**	9.5-10.4	years	(f)
22.	10.5-11.4	years	(m)	**23.**	10.5-11.4	years	(f)
24.	11.5-12.4	years	(m)	**25.**	11.5-12.4	years	(f)
26.	12.5-13.4	years	(m)	**27.**	12.5-13.4	years	(f)
28.	13.5-14.4	years	(m)	**29.**	13.5-14.4	years	(f)
30.	14.5-15.4	years	(m)	**31.**	14.5-15.4	years	(f)
32.	15.5-16.4	years	(m)	**33.**	15.5-16.4	years	(f)
34.	16.5-17.4	years	(m)	**35.**	16.5-17.4	years	(f)
36.	17.5-18.4	years	(m)	**37.**	17.5-18.4	years	(f)
38.	18.5-19.4	years	(m)	**39.**	18.5-19.4	years	(f)
40.	19.5-20.4	years	(m)	**41.**	19.5-20.4	years	(f)
42.	20.5-29	years	(m)	**43.**	20.5-29	years	(f)
44.	30 – 39	years	(m)	**45.**	30 – 39	years	(f)
46.	40 – 49	years	(m)	**47.**	40 – 49	years	(f)
48.	50 – 59	years	(m)	**49.**	50 – 59	years	(f)
50.	60 – 69	years	(m)	**51.**	60 – 69	years	(f)
52.	70 – 79	years	(m)	**53.**	70 – 79	years	(f)
54.	80 – 82	years	(m)	**55.**	80 – 82	years	(f)

The data obtained by the anthropometric measurement have been statistically analyzed and arranged in graphs, diagrams and tables. Below some of them are presented, providing the necessary data [10].

Table 4.3 Average values of body height/length (cm) of young people from 0.0 up to 20.4 years of age by gender

Age categories	Gender			
	Male		Female	
	Number	Average	Number	Average
up to 3 months	296	55.8	172	54.8
4-6 months	234	65.6	192	65.4
7-9 months	237	72.6	171	69.7
10-12 months	277	76.4	154	74.8
13-15 months	250	80.3	144	79.5
16-18 months	263	84.2	195	82.9
19-24 months	392	86.8	211	86.5
25-30 months	290	92.6	224	90.9
2.5-3.4 years	455	98.8	383	97.1
3.5-4.4 years	452	107.4	360	105.6
4.5-5.4 years	506	114.6	472	113.4
5.5-6.4 years	549	121.1	524	120.1
6.5-7.4 years	608	126.9	599	126.0
7.5-8.4 years	629	131.8	628	130.9
8.5-9.4 years	576	136.8	650	136.3
9.5-10.4 years	652	143.2	577	142.1
10.5-11.4 years	507	148.1	521	148.9
11.5-12.4 years	516	154.3	506	154.9
12.5-13.4 years	492	160.8	476	160.5
13.5-14.4 years	526	167.4	525	163.9
14.5-15.4 years	502	172.8	559	165.1
15.5-16.4 years	520	176.4	523	165.4
16.5-17.4 years	504	177.8	555	165.4
17.5-18.4 years	508	178.6	549	166.0
18.5-19.4 years	527	179.2	458	166.3
19.5-20.4 years	466	179.0	426	166.2

As can be seen from Table 4.3, the difference in the length of boys amounts to 20.6 cm (from 55.8 cm to 76.4 cm) between the first age group (up to 3 months) and the fourth age group (10 to 12 months). After the first year of life a very intensive growth continues, and during the second year of life the difference in height between the fourth age group (from 10 to 12 months) and the seventh age group (from 19 to 24 months) amounts to 10.4 cm (from 76.4 cm to 86.8 cm). After the second year of life the growth decelerates, ranging from 5 to 7 cm annually. In the first few years the growth is faster, followed by prepuberty deceleration and afterwards by pubertal growth spurt. The average height of a boy between 18.5 and 19.4 years of age amounts to 179.2 cm. The difference in length of girls between the first age group (up to 3 months) and the fourth age group (from 10 to 12 months) amounts to 20 cm (from 54.8 cm to 74.8 cm).

The average body length of female babies at the age of 3 months is 54.8 cm. After the first year of life a very intensive growth continues during the second year of life so that the difference in height between the fourth age group (from 10 to 12 months) and the seventh age group (from 19 to 24 months) amounts to 11.7 cm (from 74.8 cm to 86.5 cm). After the second year of life the growth decelerates, ranging from 5 to 9 cm annually. It comes to a pubertal growth spurt earlier than in boys, and the growth almost ceases after the age of 14 years. The average height of girls at the age of 18.5 to 19.4 years finally reaches 166.3 cm.

By comparison the height values in girls with boys in all age groups the length/height of male subjects is greater (Fig. 4.2 and Table 4.3). The differences are greater during the first years of life, afterwards they decrease, and at the beginning of puberty they increase and remain that way up to the end of growth [10].

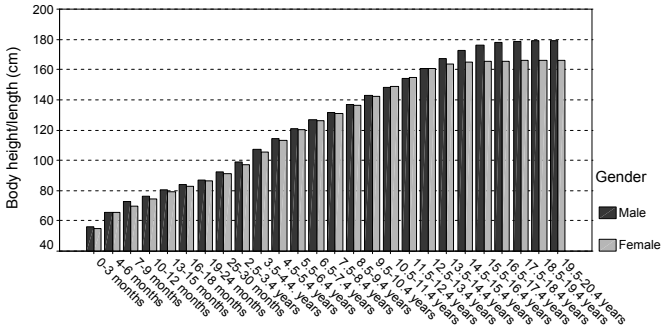

Fig. 4.2 Average values of body height/length by age groups and gender

Some of scatter plots with comments are shown below.

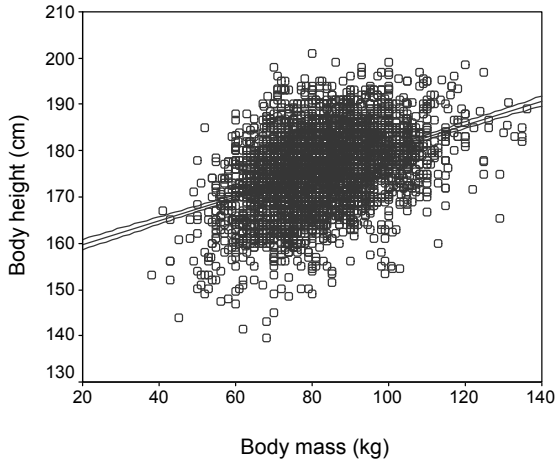

Fig. 4.3 scatter plots with relationship between the body height and mass in adult men

A scatter plot (Fig. 4.3) with the corresponding regression straight line and marked 95% band confidence show the relationship between the body height and mass in adult men. Regression straight line represents an evaluation of body height (TV) depending on body mass (MAT) according to the equation: Tv = a+b (MAT) where a = constant b = regression coefficient showing the amount of the growth of body height in relation to body mass, meaning that body height increases by 2.5 mm with body mass increasing by 1 kg and vice-versa

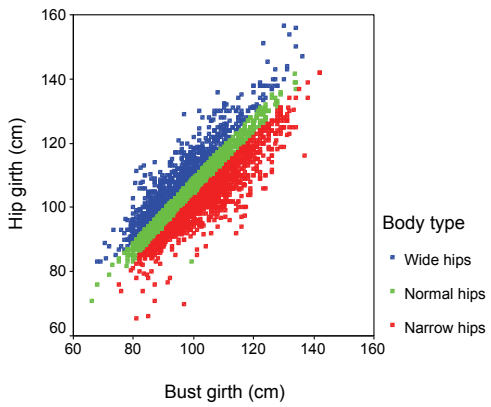

Fig. 4.4 Layout of female body type according to ISO standard in the scatter plot of bust and hip girth

Figure 4.4 shows a scatter plot of bust and hip girths in women. Their layout is marked according to ISO standard. As it is seen in the figure, three groups of hip girths belong to each bust girth and vice-versa.

The layout of the female body type determined according to EN is shown in the scatter plot of their bust and hip girths (Fig. 4.5). Each of seven body types is realized according to the standard-defined groups of bust and hip girths.

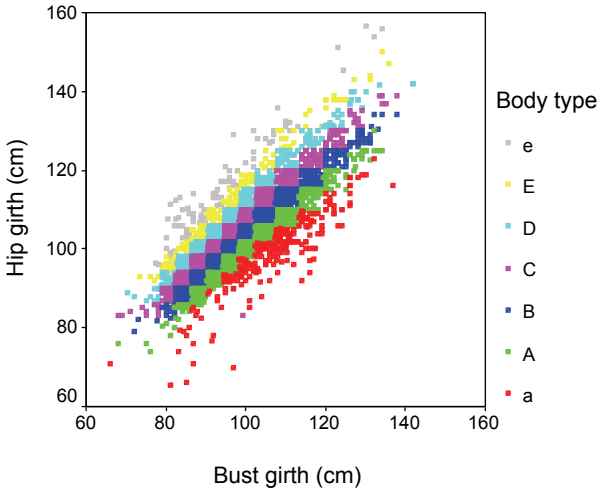

Fig. 4.5 Layout of the female body type according to the EN scatter plot of bust and hip girths

Body types are:
1. a-type – specially narrow hips
2. A-type – very narrow hips
3. B-type – narrow hips
4. C-type – normal hips
5. D-type – wide hips
6. E-type – very wide hips and
7. e-type – specially wide hips

5. Conclusion

Based on investigations done on the national sample of the population of the Republic of Croatia it may be said that the population with body proportions pursues the growth and development trend of mideuropean countries. Men are on average 175.8 cm and women 163.1 cm high. Average body mass in men amounts to 82.3 kg and in women to 68.2 kg.

The significance of anthropometric measurements for the whole population is unquestionable, but concerning the population of children and young people additional meanings become manifested. By measuring children and young people trends of measured values through time or generations can be pursued. Thus we can obtain data for our population over specific periods of time and the possibility for comparing individual values and changes in body shape. Moreover, it is also possible to make comparisons with other populations that can be similar or completely different in their characteristics. Regarding the similarities or dissimilarities of the compared populations we can investigate the influence of different factors on growth and development across the whole panoply from genetic and hereditary ones on the one hand and to social conditions on the other hand. Thus, we can see

how much a period was stimulating to growth and development or vice-versa. The development of certain predictions for the future makes all this possible.
By taking anthropometric measurements and comparing them over time changes in physical dimensions are observed and their impact on health and quality of life is explored.

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