

DEVELOPMENT TRENDS OF ANTHROPOMETRIC SYSTEMS AND CLOTHING SIZES**Darko Ujevic****Faculty of Textile Technology University of Zagreb
Zagreb, Croatia****Dubravko Rogale****Faculty of Textile Technology University of Zagreb
Zagreb, Croatia****Larry C. Wadsworth****University of Tennessee
Knoxville, TN****Isak Karabegovic****Technical Faculty University of Bihac
Bihac, Bosnia and Herzegovina****Tonci Lazibat****Graduate School of Economics & Business University of Zagreb
Zagreb, Croatia****Abstract**

Anthropometry may be defined as the science that deals with human body measurement. The development of clothing sizing systems has been dated from 1901 when the United States Government established the National Bureau of Standards (NBS).

Within the scope of the program of the Innovation and Technological Development of Croatia (HITRA) and its subprogram (TEST) the Croatian Anthropometric System (HAS) supported by the Ministry of Science, Education and Sports is being realized. The project was instituted last year and will have been finished by the end of 2005. Anthropometric measurements are being made in all Croatian counties (Ujević, 1999) and in the City of Zagreb, including a total of 30,000 subjects from birth to the age of 82 years divided into 53 age groups. For the needs of the project the following new equipment has been developed and advanced: one-arm and two-arm anthropometer, protractor for precise measuring shoulder slope. This is the first systematic anthropometric measurement in the Republic of Croatia based on the ISO standards. An interdisciplinary specialist team with different profiles is working on the project. Within the scope of field measurements over 200 authorized measurers are employed who were previously educated at two seminars organized at the Faculty of Textile Technology of the University of Zagreb.

1. Introduction

The program of the Innovation and Technological Development of Croatia (HITRA) was launched in May 2001 and marked a turning point of the scientific and technological policy of Croatia. It was the first step towards the creation of the Croatian innovation system, firstly applied by Christopher Freeman in the 70-ties of the 20th century, who is one of the creators of evolutionary economics in order to emphasize the deficiencies of the U.S. technology and science policy in comparison with the postwar development of Japan (Švarc, 2004). Today, in the time of knowledge economy many countries have introduced innovation policy as a new paradigm of economy development which replaces capital and physical work with knowledge production and its market application and innovation respectively. Titles as "Estonia Based on Knowledge", "Promotion of Innovation in Poland", "Korea and Knowledge Economy", "Towards Innovative Economy" in Canada, "Towards Society of Knowledge" in Finland illustrate the essence of innovation programs used by countries world wide to support the production and exploitation of knowledge and innovation, applying well-considered policy.

The first congress of Croatian scientists from Croatia and abroad (Zagreb-Vukovar, 15-19 November, 2004) attended by over one thousand participants evidently indicated that the time for a fundamental turning point to a new development paradigm based on innovations, technical training, connection between knowledge, industry and new technologies had come.

The Innovation and Technological Development of Croatia (HITRA) as one of the strategic directions starts from the assumption that the revitalization of research in economy as well as market exploitation of knowledge created in the public scientific research sector becomes a key issue of economic renewal, and industry-science collaboration with the support of the government is a key political issue. HITRA is being conducted under the auspices of Ministry of Science, Education and Sports within the framework of two mutually complementary programs: Program of Technological Projects (TEST) and Development Program of Knowledge-Based Companies (RAZUM).

One of the most significant projects launched is a complex technology research and development project: Croatian anthropometric system (HAS) within the HITRA program and within its TEST subprogram funded by the Ministry of Science, Education and Sports. Together with the chief researcher and project manager professor D. Ujević approximately 25 experts of different profiles (interdisciplinary team) take part in the program (Čatić, 2004, Božičević, 2004, Ujević, 2004).

2. Development problems of anthropometric measurements

Clothing size designation serves as a communication among manufacturers, salesmen and consumers. The label of individual clothing item contains a list of clothing sizes as numerals and letters. Letters symbolize the country, and numerals symbolize the clothing size of this country (1). The development of clothing sizing systems has been dated from 1901 when the United States Government established the National Bureau of Standards (NBS), a non-regulatory agency for the purposes of measurement standardization in science and industry. In 1921 the first report on an US anthropometric survey with clothing sizing conducted on approximately 100,000 men during demobilization at the end of the First World War was published. During 1937-1941 a US survey of clothing sizes for approx. 147,000 boys and girls conducted across the USA was published. In 1958 the National Bureau of Standards published the CS 215-58 standard entitled "Body Measurements for the Sizing of Women's Patterns and Apparel" based on the data analysis during 1939-1940. In 1970 the NBS Voluntary Product Standard (PS 42-70) was published.

In 1988 the U.S. Army Anthropometric Survey (ANSUR) was completed and published. It included the body measurement of 1774 men and 208 women for designing and military clothing sizing. American Society of Testing and Materials (ASTM) published the updated standard known as D5585-94. SIZE USA was launched in 2002 and completed in 2003 as an anthropometric project in 13 U.S. cities on 10,800 subjects (Armstrong, 2000, NBS, 1970, Gordon et al., 1988, Ashdown, 1998, Fashion Business International, 2002).

The International Organization for Standardization (ISO) deals with the standardization of clothing sizing systems. Its Technical Committee ISO TC 133 is in charge of the subject matter of the standardization of clothing sizing systems and designation. At the first London meeting (1989) the ISO TC 133 divided activities into two main sections: **size designation and size system**. In subsequent years ten standards were published one of them being ISO 8559 entitled Garment Construction and Anthropometric Surveys - Body Dimensions. Up to now there has been no adopted international system of body sizes which would be applicable for the entire range of garment types for an individual population group (women's and men's wear, girls' and boys' wear and infants' wear) (Čatić, 2004, Ujević, Oct. 2004).

ISO TC 133 has completed its work and plans. In order to use the unique system, it used body size in the form of a pictogram consisting of the standard outline of body figure with body dimensions. This direct and important designation will eliminate disharmony caused by using code designations with corresponding numbers mainly unrelated to customer body measurements.

Anthropometry is one of the anthropology methods dealing with measuring human body and finding the relationship in the size of its individual parts. In determining body measurements an anthropometer or any similar instrument and also a measuring tape are used. To make cuts, it is necessary to study a large number of proportions. It is therefore required to know anatomical body build and body proportions respectively. By proportions the regularities of the interrelationship of individual body measurements, deviations of body build from average build and the possibility of an existent deformation relevant to making cuts. The results of anthropometric measurements are used in many industry branches, from clothing industry over furniture industry to shoe industry. Anthropometric measurements and statistical analysis of these measurements can be classified into three data groups essential for the clothing production (Ujević et al., Oct. 2004, Ujević et al., May 2004, Ujević et al., 2003, www.scepdic.com, Ujević et al., 2004, www.aist.go.jp/index_en.html): clothing designation systems, standard and proportional measurements and share of individual clothing sizes (Maier, 1997, Maier, 1998, Chun-Yoon and Jasper, 1993, Szivoczka, 2002, Ujević et al., 1999).

2.1 Croatian anthropometric system - development and application

More than twenty distinguished experts of different profiles and specialist technologists, anthropologists, industrial medicine specialists, pediatricians, statisticians and designers are taking part in the realization of the project "Croatian Anthropometric System" under the code TP 0117-012. In addition to scientists and specialists from the Faculty of Textile Technology, researchers coming from Institute of Anthropology, School of Public Health "Andrija Štampar", Faculties of Medicine, Zagreb and Split, Faculty of Philosophy, Osijek, and specialist consultants in economy for particular fields. Field anthropometric measurements are being conducted by more than 200 mainly young people across all Croatian counties (Ujević et al., 1999) and in the city of Zagreb. By the end of

2005 the project will encompass 30,000 subjects or 0.67% of the total population, representing a safe enough statistical indicator.

The results of the HAS project will be taken advantage of in designing and making clothing and footwear and for the purposes of health care and anthropology.

Based on the HAS-project the first systematic anthropometric measurement is being conducted because the last anthropometric measurement of the population of the former state was conducted in only one area and on a smaller sample in 1961/62, which was the basis of the standardization system JUS being still in use in the Republic of Croatia (Szirovicza, 2002, Ujević et al., 1999). On the other hand, developed countries with anthropometric measurements every 10 to 15 years considerably improve their standards.

HAS, clothing size systems and size designation systems of clothing and footwear will be harmonized with ISO and EN systems.

ISO 8559 deals with garment construction, gives a survey of body dimensions and procedures of taking of body dimensions. According to this standard the measurements are divided into:

1. Horizontal measurements
2. Vertical measurements (Table 1) and
3. Other measurements.

For taking these measurements special measuring instruments for this purpose are used such as one-arm or two-arm anthropometer, measuring tape, calipers and protractor for measuring shoulder slope.

2.2. Improvement and development of anthropometric instruments

Anthropologists use various instruments for their routine and research work in the field and the lab. The HAS-measurers use several of them in their work. In selecting anthropometric instruments for the purposes of measurements the measurer's inclination and the flawless construction of the instruments were taken into account. Before starting measurements, each measurer should adhere to the following instructions accepted at the seminars:

- all instruments shall be calibrated in the metric system
- the accuracy of the instruments shall comply with the standard vernier caliper
- measurements shall always be made by a measurer
- the same instruments shall be always used
- calibrating instruments shall be on the side of the measurer.

Basic anthropometric instruments used by measurers are as follows:

1. one or two-arm anthropometer
2. sliding caliper
3. measuring tape
4. protractor (especially designed for the purposes of the Croatian anthropometric system (HAS))
5. tool for measuring foot length and body height
6. scales.

One-arm and two-arm anthropometer

The anthropometer is a 2 meter long measuring instrument of a round or angular profile. It consists of two parts calibrated with a centimeter or millimeter scale. The movable part slides along its whole length. At one end this movable part has an arm or blade, which is placed on the anthropometric point whose distance from the base is measured. One part may be used as a sliding caliper with two arms for measuring all linear measures and spans. An one-arm anthropometer is used for measuring body height, sitting torso height, sitting height to crown, waist, hip and knee heights, crotch, whereas a two-arm anthropometer is used for measuring torso length, seat depth, and interior upper leg length. The accuracy of the anthropometer scale is 0.1 cm with a measurement accuracy of 0.5 cm. The reading is done in a quadratic opening on the central line of the opening which overlaps the measurement unit (Fig. 1) (patent application, author Ph.D. Darko Ujević).

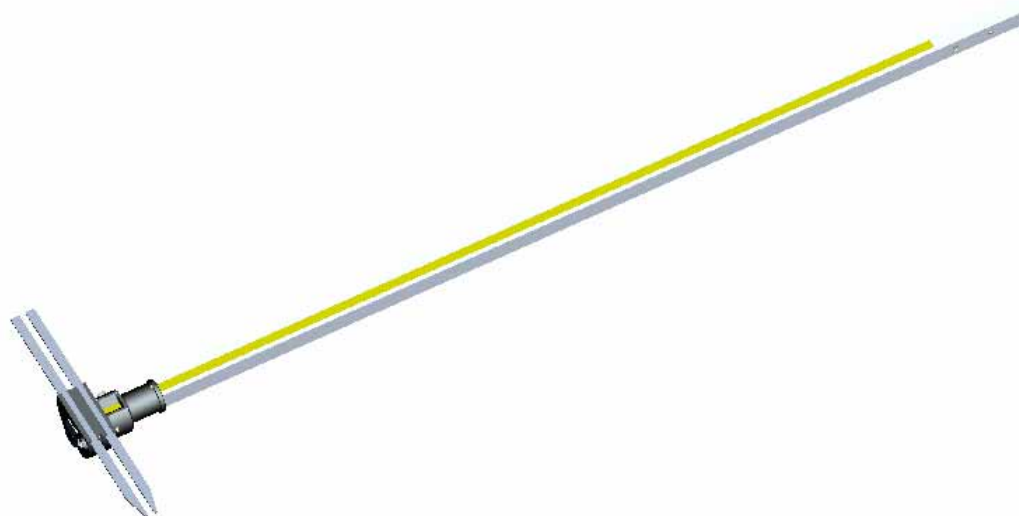


Figure 1 New two-arm anthropometer

Protractor

A specially designed protractor for the purposes of the Croatian Anthropometric System (HAS) is used for measuring shoulder slope (designed by Ph.D. G. Nikolić). Measurements are taken in such a way that the instrument is placed on the shoulder, following the line joining shoulder tip and joining point of shoulder and neck. Degree values are read when there is air between marks, Fig. 2.



Fig. 2 Protractor for measuring shoulder slope

Table 1: Overview of characteristic vertical anthropometric measurements

No.	Measurement name	Measurement designation	Measuring instrument
1.	Stature	TV	One-arm anthropometer
2.	Trunk length	DTR	Two-arm anthropometer
3.	Waist height	VST	One-arm anthropometer
4.	Hip height	VBO	One-arm anthropometer
5.	Seat depth	DS	Two-arm anthropometer
6.	Knee height	VKO	One-arm anthropometer
7.	Ankle joint height	VSZ	Sliding caliper
8.	Sitting trunk height	SVT	One-arm anthropometer
9.	Scye depth	DO	Measuring tape
10.	Back length	DL	Measuring tape
11.	Length: 7th cervical vertebra to knee	DDK	Measuring tape
12.	Length: 7th cervical vertebra to foot	DDS	Measuring tape
13.	Bust height (from 7th cervical vertebra	VVG	Measuring tape
14.	Front part height (from 7th cervical vertebra)	VVP	Measuring tape
15.	Bust height (without neckline)	VG	Measuring tape
16.	Front part height (without neckline)	VP	Measuring tape
17.	Hip depth	DBO	Measuring tape
18.	Trunk circumference	OTR	Measuring tape
19.	Total seat length	UDS	Measuring tape
20.	Shoulder circumference	ORA	Measuring tape
21.	Upper arm length	DNA	Measuring tape
22.	Sleeve length	DR	Measuring tape
23.	Sleeve length from 7th cervical vertebra	DR7	Measuring tape
24.	Inside sleeve length	UDR	Measuring tape
25.	Trouser length	DHL	Measuring tape
26.	Inside upper leg length	UDK	Two-arm anthropometer
27.	Crotch length	DKO	One-arm anthropometer
28.	Sitting height to crown	SVTJ	One-arm anthropometer
29.	Shoulder slope	KRA	Protractor
30.	Body mass	MAT	Scales

2.3 International Standard ISO 9407: Shoe sizes - Mondopoint system of sizing and marking

ISO 9407 standard describes the basic characteristics of shoe size system and applies to all types of footwear. The standard describes the method of measuring foot length and width (Gordon et al., 1988).

Table 2 Characteristic anthropometric foot sizes

No.	Measurement name	Measurement designation	Measuring instrument
25	Foot length	DST	Sliding caliper
57	Foot width	ŠST	Sliding caliper
58	Foot girth	OST	Measuring tape
59	Instep girth	ORI	Measuring tape

2.4. Number of measurements of anthropometric sizes within the project Croatian Anthropometric System

Based on the conducted analysis by the experts participating in the project "Croatian Anthropometric System" a handbook for field measurements was written. It defines the number of anthropometric measurements for each population (Ujević et al., Oct. 2004) as well as the number of 53 age groups from child birth to the people aged 82 years (Ujević et al., Oct. 2004, Ujević et al., May 2004).

The total number of measurements is:

- 57 anthropometric measurements in women
- 54 anthropometric measurements in men

- 30 measurements in children from 5.5 to 10 years of age
- 15 measurements for children to 5.4 years of age.

Body height (stature) (TV)

When measuring stature, the subject should stand on a flat surface without shoes and socks, with heels put together, and fully outstretched. The shoulders are relaxed. By moving the processus mastoideus slowly, the head position is adjusted in such a way that the "Frankfurt horizontal" is brought into a horizontal position. Along the horizontally placed tape measure a triangle is moved until it touches the top of the head and the obtained value is expressed to the nearest 0.1 cm.

Body length (for children)

This anthropometric measurement for children is taken in several different ways. Measurements in the child's lying position are made when the child is about 3 years old. For older children this kind of measurement serves only for the measurement of sitting length (height). During measuring the so called "Pirquet's trough" is used. "O" value lies on the child's occiput; whereas by moving the wooden part towards the caudal body portions of the child its length (height) is read in centimeters on the marks of the trough.

Shoulder slope (KRA)

Value of angle of inclination is taken with a protractor placed on the shoulder and it traces the line joining shoulder tip and point connecting shoulder and neck.

3. Conclusions

Anthropometric measurements are of great and practical importance for each country. Among other things, Croatian anthropometric system will provide indispensable data about the clothing and footwear industry (stature and development of the population in the counties, data about the design and shape of the shoe last), data about standard specifications of furniture for schools, hospitals, offices, public institutions, which is one of the prerequisites to preventing the occurrence of orthopedic deformities, especially in children, data about mechanical engineering and road building (height and range of operating different machines and instruments), about the industry of personal protective equipment and safety equipment, Croatian Army and Police (caps, masks, gloves, special and protective clothing, guards), the automotive industry (seats), tourist services and nature reserves (rangers), medical and hospital services etc.

Based on the results of anthropometric investigations it is absolutely necessary to create a size system for clothes and footwear that have to be harmonized with ISO standards and EN recommendations. Clothing and footwear are designed and constructed based on anthropometric measurements being the basis for size labeling system in many countries.

The results of anthropometric measurements and their statistical analysis of a representative population sample will be used for the determination of the national system of clothing and footwear sizes, which is the basic task and purpose of the Croatian Anthropometric System (HAS).

During the realization of the project the partial use of a 3D body scanner for certain body measurements was taken into consideration. However, it was given up owing to difficult transport, calibration, running-in and impossibility of purchasing a number of portable scanners as well as owing to professional commitment what is caused by using the scanner for determining body measurements of small boys and girls who should stay in a dark room for a while. Therefore, a classic measurement procedure was conducted with anthropometers, protractors, calipers, measuring tape and digital scales.

The results of the Compound technological projects (STIRP) of the Croatian Anthropometric System will make a substantial contribution to the improvement of the existing system of clothing sizes and to the establishment of a new system and size labelling system. In this way the export status of our clothing and footwear industry will be facilitated in the EU countries and the world.

The results of this project will show what directions and dynamics exist in secular changes of the growth and development of children and young people in different regions of the Republic of Croatia, and whether there are

differences in different socioeconomic groups indicating the need for an appropriate intervention in order to promote and protect the health of children and young people. Besides scientific value, the knowledge gained in this way will be of great significance in promoting the healthcare of children and young people.

The result of this project with the aim of defining the garment size system in Croatia will represent a substantial contribution to approaching and harmonizing with the international systems of these sizes. By developing and using new anthropometric instruments quality, measurement speed and accuracy of field measurements of a multitude of subjects were improved.

The interest for determining garment sizes will grow because it is expected that the number of older customers will double by 2030. This is the reason why sizing systems are to be updated from time to time in order to ensure a correct fit of ready-to-wear clothing and footwear (Ujević et al., 2003, Szivovicsa, 2002, Labat and Delong, 1990).

Croatian anthropometric system is realized through the HITRA program within its TEST subprogram supported by the Ministry of Science, Education and Sports.

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