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MEASURING OBESITY -
CLASSIFICATION AND DESCRIPTION OF ANTHROPOMETRIC DATA

Report on a WHO Consultation on the Epidemiology of Obesity

Warsaw
21-23 October 1987

National Food and Nutrition Institute
Warsaw

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TARGET 16

Promoting positive health behaviour

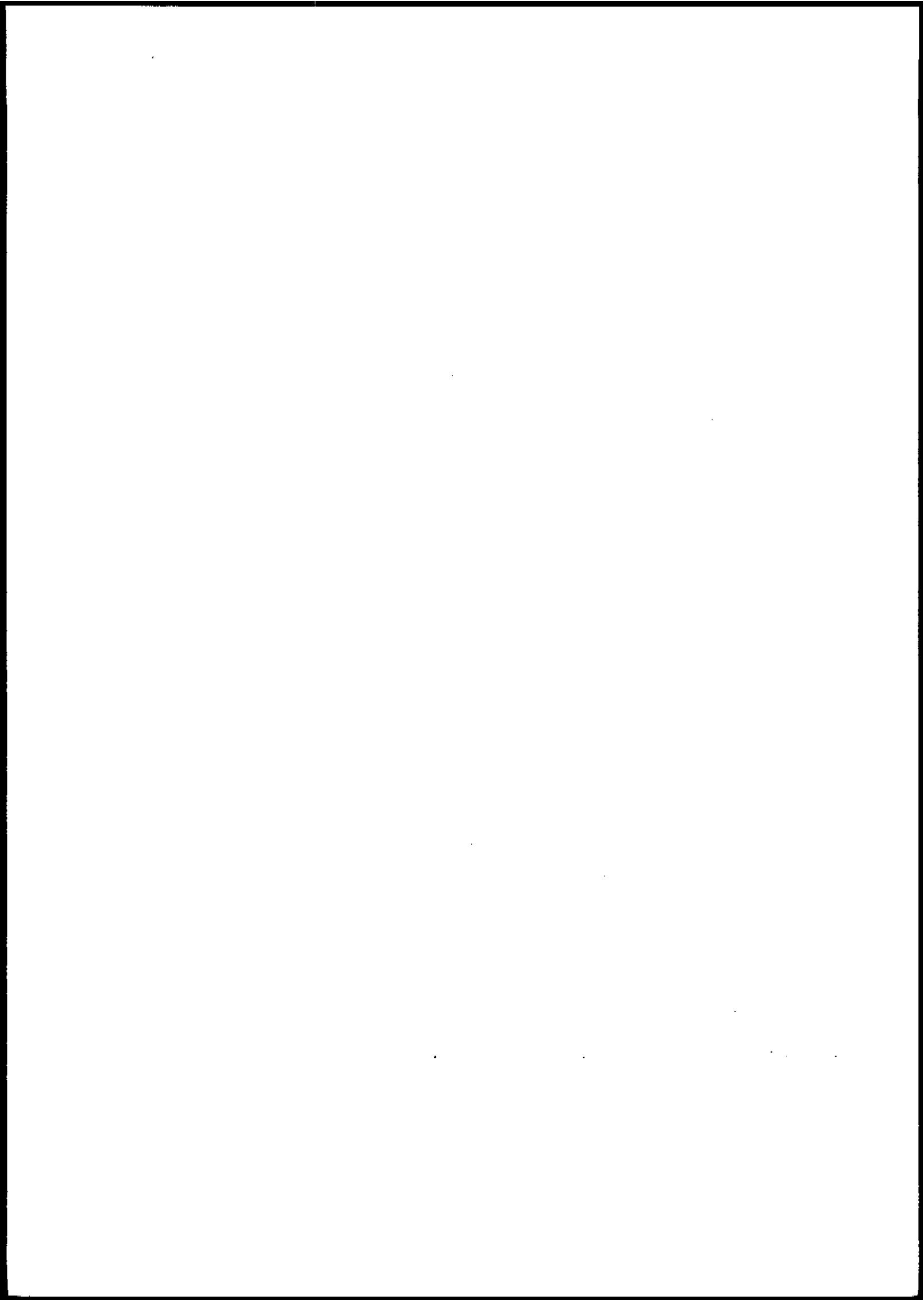
By 1995, in all Member States, there should be significant increases in positive health behaviour, such as balanced nutrition, nonsmoking, appropriate physical activity and good stress management.

Index:

OBESITY
ANTHROPOMETRY
EPIDEMIOLOGIC METHODS

CONTENTS

	<u>Page</u>
1. Introduction	1
2. What do we want to describe?	1
3. Recommendations for data collection	2
3.1 Height/length	2
3.2 Weight	2
3.3 Waist circumference	2
3.4 Hip circumference	3
3.5 Subscapular skinfold measurement	3
3.6 Upper thigh circumference	3
3.7 Triceps skinfold measurement	3
3.8 Upper mid-arm circumference	4
3.9 Biceps skinfold measurement	4
3.10 Supra-iliac skinfold measurement	4
3.11 Wrist and knee breadth	4
3.12 Abdominal and thigh skinfold	4
4. Analysis of measurements	4
4.1 Non-response	4
4.2 Body mass index	4
4.3 Classification of obesity	4
4.4 Distribution of the BMI in a population	5
4.5 Waist/hip ratio	6
4.6 Waist/thigh ratio	6
4.7 Classifications not recommended	6
4.8 Selection of age ranges	6
4.9 Anthropology and physiology in ongoing obesity research	7
4.10 Risk assessment in prospective (longitudinal) studies	7
References	7
Annex 1. Examples of inconsistencies in criteria used for defining obesity and overweight in selected national, regional and community surveys	8
Annex 2. Waist/hip ratio and health hazards - pathogenetic aspects	14
Annex 3. Measuring skinfolds and circumferences	15
Annex 4. Epidemiological background	17
Annex 5. List of participants	21



1. Introduction

Several meetings have in the past few years suggested various types of norms for the description and assessment of obesity (1-4). However, it has been suggested that it would be useful to have a set of simple recommendations and norms for the classification of obesity emanating from WHO, so as to be able to describe populations anthropometrically with greater precision than has been done to date. In particular, it would be useful to have recommendations for more standardized presentations to allow intercountry and intracountry comparison. Until now, very few international comparisons have been possible, mainly because of the way the data has been analysed and presented (see Annex 1).

The intention of this meeting was therefore to address this problem and to produce recommended methods and standards for the measurement of populations, and for the analysis and presentation of data.

It was realized that measuring children posed several problems, which probably warrant a specific meeting. This aspect was therefore not discussed at the present meeting, which dealt only with the measurement of adult populations.

A clear distinction has to be made between standards intended on the one hand for diagnosis and advice to individuals, and on the other for the description of populations. It was agreed that the meeting would concentrate on standards of the latter type. Recommendations are made for describing total body fatness, as well as its distribution, in large-scale population studies. At a later stage in the analysis of data from such studies, it might be possible to relate the anthropometric measurements to health parameters as well.

Most diseases related to obesity are multifactorial in origin. There is also a growing body of information suggesting that obesity as such may sometimes be less closely related to certain diseases as the distribution of the fat in the body; in other words, the latter factor will often be of considerable independent importance. It is therefore becoming obvious that simple measurements of height and weight do not suffice to derive various weight/height ratios.

2. What do we want to describe?

It was emphasized that, except for some very clear-cut morbidity situations, "fatness" is a continuous phenomenon, presenting no natural cut-off points. Any categorization will therefore be arbitrary to some degree.

Measurements of height and weight should be routinely taken in all circumstances. Large data masses from various periods in time are already available which, when reanalysed, will allow the establishment of chronological changes.

With new ways of describing regional body fat distribution, it is clear, however, that even on a large population scale it is now possible to add simple measurements that will provide indices which have considerably more predictive power in relation to risk conditions and diseases than weight/height indices alone.

Practical aspects have to be considered, such as what kind of data is it feasible to expect in large-scale investigations without too high a cost for equipment and training?

Measuring the circumference of various parts of the body can be done with relatively simple and short training of investigators and with cheap equipment, and does not take much time to perform.

Skinfold measurements require suitable calipers, a slightly higher degree of method standardization and more investment in the training of personnel. However, these measurements have the advantage of being unequivocal in that they actually measure the presence of fat. The relationship of skinfold to fatness may of course vary among populations, and this has to be taken into consideration. When compared with, for example, biochemical tests that are performed routinely on large population samples, the requirement for skinfold measurements is modest.

3. Recommendations for data collection

The meeting recommended that, in all population surveys where anthropometric measurements are made, the following measurements should be included and performed as described.

The measurements are presented in descending order of importance. Their actual inclusion or exclusion will, of course, be decided by the resources available as well as the intentions of the study.

It was none the less felt that the first five measurements are the most important ones, and those that at present seem to have the most potential for describing anthropometrical indicators of some aspects of the health of a population.

For some practical considerations regarding measurements of skinfolds and circumferences, see Annex 3.

3.1 Height/length

Height should be measured on the subject (without shoes) with the heels together and with the head in the so-called Frankfurt plane (see Fig. 1) in a horizontal position. The subject should breathe in deeply and reach up to a maximum height with the legs stretched but the feet flat on the ground (this procedure is recommended to reduce variability).

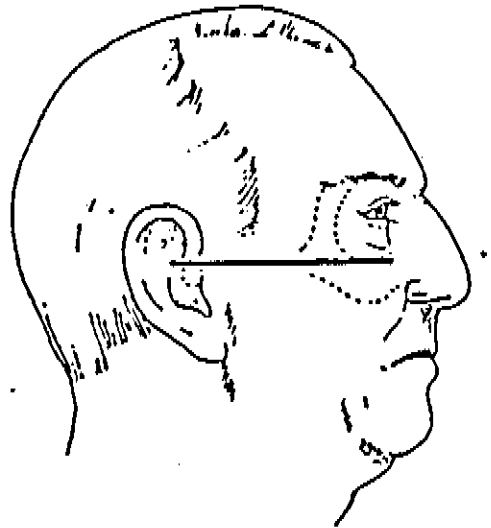
3.2 Weight

Weight should be recorded to the nearest 0.5 kg of the subject, wearing no clothes or only light underwear.

3.3 Waist circumference

The measurement should be done midway between the lower rib margin and the iliac crest, using the following procedure: mark the level of the lowest rib margin, palpate the iliac crest in the midaxillary line and mark this level on the skin, apply the elastic tape (see Annex 3) horizontally midway between the lowest rib margin and the iliac crest and measure the circumference over the tape. It is recommended that the observer should sit in front of the subject.

Fig. 1. The Frankfurt plane



Horizontal line is the Frankfurt plane, which should be in a horizontal position when height is measured.

Source: Seidell et al. (5).

For general considerations, see Annex 3.

3.4 Hip circumference

The measurement should be done at the point yielding the maximum circumference over the buttocks with the tape held horizontal. For procedure, see section 3.3 and Annex 3.

3.5 Subscapular skinfold measurement

The skinfold is picked up just below the tip of the right scapula. The natural potential crease that is lifted to form this fold runs at an angle of about 45° downwards from the spine.

For general considerations, see Annex 3.

3.6 Upper thigh circumference

Although there is relatively little experience in the measurement of this parameter, it may be very promising, and its inclusion in a population survey is therefore recommended. For the moment, it is recommended to measure the circumference around the right thigh just below the gluteal fold.

3.7 Triceps skinfold measurement

A mark should be made at the back of the arm, half-way between the inferior border of the acromion process and the tip of the olecranon process and directly in line with the point of the elbow and acromion process. The skinfold is measured at this mark.

3.8 Upper mid-arm circumference

This measurement is included mainly because it is very commonly made in most parts of the world and yields some information about muscle mass.

The measurement is made at the same point as the skinfold measurement, as described above, with the arms hanging down.

3.9 Biceps skinfold measurement

This measurement is included not because it is seen as particularly important but because it is very easy to perform in connection with making a triceps skinfold measurement. It is also one of the four skinfold measurements commonly used to assess fatness (6).

The skinfold is picked up on the front of the arm directly above the centre of the cubital fossa. The calipers should be applied at the skinfold at the level of the mid-point of the belly of the biceps muscle, with the arm hanging in a relaxed position.

3.10 Supra-iliac skinfold measurement

The vertical skinfold is picked up immediately above the anterior superior iliac spine in the mid-axillary line.

3.11 Wrist and knee breadth

For the knee measurement, the subject sits on a table with knees bent to a right angle (90°), and the width across the outermost parts of the lower end of the femur is measured. Pressure is exerted to compress the tissues. This measurement can be done using a sliding caliper or anthropometer.

Wrist breadth is measured across the styloid processes (oblique to the long axis of the arm), with pressure to compress the tissues and the forearm pronated. This measurement can be done using a sliding caliper or anthropometer.

3.12 Abdominal and thigh skinfold

As has often been demonstrated, these points on the body can be difficult to locate and measure and do not necessarily yield better information than any of the other measurements discussed above. It is therefore not recommended to use them.

4. Analysis of measurements

4.1 Non-response

The importance of a thorough analysis of non-responders or refusals is underlined. It should be clearly assessed how non-response affects the representativeness of the sample.

4.2 Body mass index

It was strongly recommended to use the body mass index (BMI), which is also called the Quetelet index, as an important component in the presentation of the material. It is a reasonable index of population fatness. It has shown reasonably good correlation with body fatness (by densitometry, etc.)

and with many health indices, and allows for a sensible classification of the material. The relationship between total mortality risk and the BMI constitutes a U-shaped curve (see Annex 4), and hence delineations of fatness are not possible.

The use of the BMI as an indicator of health risk is sometimes suggested at levels that are astonishingly precise. It appears, as is evident from the data presented in Annex 4, for instance, somewhat unrealistic to suggest that BMI can be used in any very exact manner. The range of BMI values on which health advice is going to be based is clearly likely to vary in different communities as a result of many confounding factors such as diet, smoking and levels of physical activity.

4.3 Classification of obesity

It is difficult to state accurately the different degrees of obesity at which there will be specified increases in the risk of morbidity.

When long-term studies are conducted, e.g. the Norwegian study (Annex 4), the lowest mortality rates are observed in those with a BMI value between about 22 and 30. Separating smokers from nonsmokers would yield a similar picture, but with smokers at all levels of body weight having a substantially higher risk of premature death than nonsmokers.

Smoking thus confounds the relationship between excess weight and mortality, since smoking is not only very hazardous but also limits weight gain so that smokers are thinner than nonsmokers. Thus smoking-related diseases, e.g. respiratory diseases and lung cancer, and deaths are found particularly in lighter weight individuals, whereas in heavier men and women deaths from diabetes and cardiovascular diseases are found more frequently.

An international classification of obesity has been proposed (7) and widely accepted, based on the following arbitrary range of BMI values:

- below 20;
- 20-25;
- 25-30;
- 30-40;
- above 40.

The different degrees of heaviness correspond to increasing amounts of body fat, but there is a substantial variation between individuals at each BMI level.

Epidemiological analyses of mortality and morbidity are usually assessed in relation to the BMI rather than to more specific measures of fatness, e.g. skinfold thickness, so the nutritional assessment of groups and populations should be based on the BMI.

Given the modest differences in mortality risk between a BMI value of 20 and 30 (see Annex 4, Fig. 1), it is suggested that a BMI value of 30 and above should be specified as indicating "a high degree of fatness". The terms *overweight* and *obesity* imply a health risk that may vary from country to country, depending on prevailing risk factors such as diet and prevalence of smoking.

In practice, a BMI value of 30 or more should be taken as signifying obesity.

4.4 Distribution of the BMI in a population

In addition to the broad classification of the BMI as described above, it is recommended to present the distribution over smaller intervals with interval widths of up to two BMI units. In this way, the total frequency distribution of the BMI will be described, including the mean and standard deviation. If data size allows, it is recommended to describe the data in a similar way in subgroups, such as age categories, separately.

To make meaningful comparisons between populations and subpopulations possible, some potentially confounding factors need to be measured: age, social class (occupation, educational level), degree of urbanization and smoking habits.

4.5 Waist/hip ratio

Older and more recent cross-sectional data show that the localization of adipose tissue might be an important indicator of health hazard. These data have been strengthened by recent prospective epidemiological studies (8). The ratio is a simple indicator of abdominally located adipose tissue, both subcutaneous and intra-abdominal. It seems possible that this is an indicator of health hazard that is separate from obesity, and it is therefore recommended to include it in the analysis. The ratio increases with age and varies according to sex.

4.6 Waist/thigh ratio

There are indications that this ratio might be as sensitive as a health risk indicator as the waist/hip ratio. However, most of the present information is based on the waist/hip ratio. More data on these ratios are needed.

4.7 Classifications not recommended

A number of classifications that have been common but do not allow international comparison should not be used in the presentation of population data. These include "% relative weight", "% above mean/average weight", "% above normal weight" or "% above desirable weight", "% above median weight" or "above Y percentile".

The Broca index has been in common use, but the group felt that this is not necessarily indicated (see comments in Annex 4).

4.8 Selection of age ranges

The selection of age ranges in the final analysis and presentation will of course depend on the size and shape of the study. It is, however, important in the presentation to follow the established conventions of presentation of epidemiological material, indicating, for example, ten-year age ranges such as 30-39 and 40-49 years and five-year ranges such as 20-24, 25-29 and 30-34 years. The important point is of course to define as accurately as possible the age range to be used.

In studies of obesity in women, it may be important to group the material so that it is possible to distinguish clearly between premenopausal and menopausal women.

4.9 Anthropology and physiology in ongoing obesity research

Annex 2 gives an overview of current obesity research as presented in the Consultation, linking anthropometric data with various biochemical and biological processes.

4.10 Risk assessment in prospective (longitudinal) studies

Risk assessment on an individual level. Risk ratios (relative risks) at different levels of fatness should preferably be calculated adjusting for effects of age, social class and smoking habits. Adjustments can be made using multivariate techniques (Cox regression model, proportional hazard model) or, if the size of the data set allows this, stratified analysis (e.g. looking at smokers and nonsmokers separately).

Risk assessment on a population level. The total impact of different levels of fatness in the incidence of disease can be evaluated by calculating the attributable risks. A high relative risk in a small proportion of the population (e.g. BMI 30 and above) can have a different impact on the total morbidity when compared to a moderately increased risk in a larger proportion of the population (e.g. perhaps BMI 25-29).

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Annex 1

EXAMPLES OF INCONSISTENCIES IN CRITERIA USED FOR DEFINING OBESITY AND OVERWEIGHT IN SELECTED NATIONAL, REGIONAL AND COMMUNITY SURVEYS^a

Reference	Description	Definition of Obesity (ob) and/or Overweight (ow)	Prevalence Estimate (m: males, f: females)
Malina RM et al. <i>Estimated overweight and obesity in Mexican American school children</i> Int J Obes 1986;10:483-91.	6-17 year olds n=1269 in 1972 n=868 in 1983 (USA)	ow: ≥ 90 percentile (for both BMI and triceps) ob: ≥ 95 percentile (for both BMI and triceps) using NHANES1 as reference	1972:2.7% (m); 3.2% (f) 1983:6.7% (m); 2.5% (f) 1972:1.6% (m); 0.3% (f) 1983:10.3% (m); 2.1% (f)
Millar WJ et al. <i>The Prevalence of overweight and obesity in Britain, Canada, and United States.</i> Amer J Public Health; 1987;77:38-41	Dept of Health and Social Security(1980), Canada Fitness Survey (1981) NHANES2 (1976-80) (UK, Canada, USA)	ow: BMI≥25.1 ob: BMI≥30	UK:43% (m); 34% (f) Canada:47% (m); 29% (f) USA:52% (m); 37% (f) UK:8% (m); 9% (f); Canada:9% (m); 8% (f) USA:12% (m); 15% (f)
Patterson RE et al. <i>Factors related to obesity in preschool children.</i> J Am Diet Assoc 1986;86:1376-81	n=94 child-parent pairs (USA)	ow: triceps≥75 percentile ob: triceps ≥ 90 percentile using NHANES as reference	23.4% (children) 29.8% (parents) 7.5% (children) 10.6% (parents)
Gortmaker SL et al. <i>Increasing pediatric obesity in the United States.</i> Am J Child 1987; 141:535-40	National Health Exam. Survey n=6710 (USA)	ob: triceps ≥ 85 percentile	15% by definition
Freedman DS et al. <i>Persistence of juvenile-onset obesity over eight years.</i> Am J Pub Health; 1987;77:588-92	Bogalusa Heart Study (USA)	ob: triceps ≥ 85 percentile	15 % by definition

^a Prepared by Lauren Lissner, University of Pennsylvania, with assistance from Jacqueline Reynaux, Cornell University. Citations were obtained by MEDLINE Search (National Library of Medicine, Washington, DC).

<u>Reference</u>	<u>Description</u>	<u>Definition of Obesity (ob) and/or Overweight (ow)</u>	<u>Prevalence Estimate</u>
Forman MR et al. <i>Overweight adults in the United States: the behavioral risk factor surveys</i> Am J Clin Nutr 1986;44:410-6	(USA) n=2236	ow: ≥ 120 % of 1959 Metropolitan Life Insurance Standards (MLI)	White m: 23.4% White f: 20.3% Black & Hisp. m: 27.5% Black % Hisp. f: 34.6%
Rolland-Cachera M-F et al <i>No correlation between adiposity and food intake: why are working class children fatter?</i> Am J Clin Nutr 1986; 44:779-87.	n=2440 children (France)	"fat" ≥ 85percentile ob: ≥ 97 percentile	15% by definition 3% by definition
McIntyre L et al. <i>Prevalence of hypertension, obesity and smoking in 3 Indian communities in northwestern Ontario.</i> Can Med Assoc J, 1986;134:345-9.	n=668 (Canada)	ob: BMI>27(m) BMI>25(f)	age: m:25-34:~25% m:35-44:~52% f:25-34:~57% f:35-44:~72%
Keys A. <i>Coronary heart disease in 7 countries</i> , 1970, Am Heart Ass Mono 29.	Japan Greece Finland Yugoslavia Italy Netherlands United States	ow: relative weight > 100% ob: sum of triceps and subscapular skinfold > 28 mm	ow:2%; ob:2% ow:11%; ob:11% ow:15%; ob:14% ow:19%;ob:29% ow:33%; ob:28% ow:13%; ob:32% ow:32%;ow:63%
Descovich GC et al. <i>L'indagine di Brisighella: in Rapporto conoscitivo sullo stato delle indagini epidemiologiche in Italia nel campo dell'arteriosclerosi</i> , pp93-104, Consiglio Nazionale delle Ricerche, Roma 1977	Central Italy	ow: BMI > 25 in m BMI > 23 in f	35% (m) 36% (f)

<u>Reference</u>	<u>Description</u>	<u>Definition of Obesity (ob) and/or Overweight (ow)</u>	<u>Prevalence Estimate</u>
Sirata et al. <i>Epidemiological aspects and social importance of obesity. The situation in Italy compared with other developed countries.</i> Int J Obesity 1977, 1:191-206	Northern Italy	ob: 120% of standard	18% (m 30-40 yr) 29% (f 30-40 yr) 22% (m > 40 yr) 37% (f > 40 yr)
Farinaro et al. <i>Overweight and other risk factors in a working population of southern Italy;</i> in Mancini et al, <i>Medical complications of obesity</i> , pp. 229-234, Academic Press London 1979.	Southern Italy	ow: BMI=26.3-28 ob: BMI≥28.1	ow: 20% ob: 20%
Mancini et al. <i>Medical complications and Prevalence of Obesity in Italy.</i> <i>Biblica Nutr Dieta</i> , 1986;37:1-10	Risk factors for Arteriosclerosis in Italy: CNR-ATS-RF2 (Nine-region survey)	ow (male): BMI=25.1-27.9 ow (female): BMI=23.1-27.9 ob (male): BMI≥28 ob (female): BMI≥28 frank obesity: BMI≥30	e.g. frank obesity in 20-59 yr Neopolitan m: 15.3% f: 31.6%
Rosenbaum S ET al. <i>A survey of heights and weights of adults in Great Britain</i> Ann Hum Biol 1985;12:115-27	UK	ob: BMI>25 gross ob: BMI>30	e.g. m: 40-49 yr: 52% f: 40-49: 37% m & f 40-49 yr: 9%
Van Itallie T. <i>Health implications of overweight and obesity in the United States.</i> Ann Int Med 1985; 103:983-88	US NHANES 2 n=8011	ow: BMI≥ 27.8 (m) BMI ≥ 27.3 (f) (=85th percentile for 20-29 year old m&f)	26% m and f 20-75 yr
Kluthe et al. <i>Obesity in Europe.</i> Ann Int Med 1985; 103:1037-42	Austrian Health Check-up 9 Bulgarian villages (n=4198) Copenhagen (n=263)	ob: >120% Broca index > 120% Broca index >25.7 BMI	5-15% (20-40 yr) 19.1% (>35 yr) 9.9% (m 18-20 yr)

<u>Reference</u>	<u>Description</u>	<u>Definition of Obesity (ob) and/or Overweight (ow)</u>	<u>Prevalence Estimate</u>
Kluthe et al. <i>Obesity in Europe.</i> <i>Ann Int Med</i> 1985;103:1037-42 (continued)	Federal Republic of Germany (n=4709)	>115% Broca index	17.4%
		>120% Broca index	14.0% (m 30-60 yrs)
		>140% Broca index	8.0%
	German Democratic Republic (n=79 708)	>120% Broca index	14%(urban m)
			32%(urban f)
			23%(rural m)
			49%(rural f)
	Great Britain (n=5632)	>120% Broca index	5-12%(m)
			6-11%(f)
	Netherlands (n=3857)	moderate ob: 25-29.9 BMI	22% (m 19-31 yr)
			12% (f 19-31 yr)
		severe ob: ≥ 30 BMI	12% (m 19-31 yr)
			2% (f 12-31 yr)
	Norway (n=3751)	ob: >115-125% Broca	14.1% (m)
	Rumania (n=100 482)	ob: >120% MLL standards	25.4% (urban m)
			32.2% (urban f)
			22.2% (rural m)
			40.9% (rural f)
	Switzerland (n=1014)	ob: $\geq 120\%$ Broca	18.7-33.6% (m)
Beckles GL et al. <i>Obesity in women in an urban Trinidadian community.</i> <i>Int J Obesity</i> 1985;9:127-35	Trinidad (n=738)	ob: BMI ≥ 30	32% (40 yr)
			27% (74 yr)
Peckham et al. <i>Prevalence of obesity in British children born in 1946 and 1958.</i> <i>Br Med J</i> 1983;286:1237-42	UK (n=30 681)	ow: 120% of standard for age, height, sex	7% (boys, 14 yrs) 9% (girls, 14 yrs)

Reference	Description	Definition of Obesity (ob) and/or Overweight (ow)	Prevalence Estimate
Benson-Cooper D et al. <i>Obesity in a New Zealand community.</i> NZ Med J, 1975;82:115-9	n=2670 (New Zealand)	ob=120% of standard	31% (m) 40% (f)
Sveger T et al. <i>Nutrition, overnutrition, and obesity in the first year of life in Malmo, Sweden.</i> Acta Paediatr Scand, 1975;64:635-40.	n=243 (Sweden)	ow: 110-120% of standard ob: 120-140% of standard	ow: 15-23% ob: 0-6%
Ginsberg-Fellner F et al. <i>Overweight and obesity in preschool children in New York City.</i> Am J Clin Nutr 1981;34:2236-41	n=2606 (USA)	ow: \geq 120% of standard ob: \geq 130% of standard	ow: 12.2% ob: 4.7%
Jeffery RW et al. <i>Prevalence of overweight and weight loss behavior in a metropolitan adult population: the Minnesota Heart Survey experience.</i> Am J Public Health 1984;74:349-52	n=6502 (USA)	ow: BMI \geq 27 (m) BMI \geq 26 (f)	20-50% (m) 15-42% (f)
Ho TF et al. <i>The prevalence of obesity in Singapore primary school children.</i> Aust Paediatr J 1983;19:248-50	n=440 092 (Singapore)	ob: \geq 120% Harvard standard	3.95% (boys) 3.09% (girls)
Okeke EC et al. <i>The prevalence of obesity in adults by age, sex, and occupation in Anambra State, Nigeria</i> Growth 1983: 47:263-71.	n=204 (Nigeria)	ob: 120% of standard	78% (businessmen) 59% (market women) 54% (chiefs) 41% (civil servants)
Birbeck JA. <i>Obesity, socioeconomic variables and eating habits in New Zealand</i> J Biosoc Sci 1981;13:299-307	n=1586 (New Zealand)	ob: (1) >120% median w/age (2) > 140% median w/age (3) triceps > 85 percentile (4) subscaps > 85 percentile (5) severe ob: > 95 percentile (sum of skinfolds)	(1) 7-17% (2) 2-6% (3) 18-39% (4) 18-28% (5) 2-9%

<u>Reference</u>	<u>Description</u>	<u>Definition of Obesity (ob) and/or Overweight (ow)</u>	<u>Prevalence Estimate</u>
De Luise MA. <i>Obesity studies in Australia</i> . Med J Aust 1985;142: S20-25	(Australia) n=10 000 (adults) n=1024 (adults) n=5347 (adolescents) n=320 (adolescents)	ob: > 120% MLJ ob: > 130% MLJ ob: > 120% standard ob: > 120% standard	12-17% (m) 10-20% (f) 9-17% (m) 9-16% (f) 5% (m); 8% (f) 15% (m); 19% (f)
Kelly P et al. <i>Evolution of obesity in young people in Busselton, Western Australia</i> . Med J Aust 1984;141:97-99	n=928	ob: > 120% NHMRC or WHO standards	0.5-5% (m, 6-18 yr) 9% (m, ≥18 yr) 1-8% (f, 6-18 yr) 13-16% (f, ≥ 18 yr)

Note: To date, there has been no comprehensive, comparative study describing the prevalence of obesity in different nations and regions, with the notable exception of the Seven Countries Study. It is difficult to make such comparisons on the basis of published data because so many different criteria for obesity have been used to classify subjects in the various studies that have been done. To understand this problem, a literature search was done at the University of Pennsylvania Biomedical Library, using MEDLINE to locate sources. Large- and small-scale surveys were identified in which the prevalence of obesity or overweight was reported based on explicitly defined criteria. This list of surveys is not intended to be exhaustive, but rather, to illustrate that many different classification systems have been used in the characterization of obesity.

Annex 2

WAIST/HIP RATIO AND HEALTH HAZARDS - PATHOGENETIC ASPECTS

The waist/hip ratio (WHR) has been found to be closely related to disease in both cross-sectional and longitudinal studies, frequently in a graded, dose-response manner. These diseases are cardiovascular disease, stroke and non-insulin-dependent diabetes mellitus. The question then arises whether a causal association is at hand between the WHR and the different diseases concerned.

The critical component of an elevated WHR ratio is probably the mass of intra-abdominal fat. The intra-abdominal adipose tissues, particularly those drained by the portal vein, are very sensitive to lipolytic (stress) hormones and tend to release free fatty acids in excess amounts into circulation, interfering with insulin binding and its subsequent facilitation of glucose transport. Furthermore, lipoprotein synthesis in the liver is driven by portal free fatty acids. These effects may then lead to insulin resistance, hyperinsulinaemia, hyperlipidaemia and perhaps hypertension. These are all established risk factors for the diseases in question. Intra-abdominal fat in excess amounts might thus act as a risk factor generator.

Another possibility with regard to the associations between an elevated WHR and disease is that some unknown factor produces both disease and an elevated WHR. Steroid hormones might be involved here, since aberrations in the production of these hormones are known to be associated with an elevated WHR. Such aberrations might also cause accumulation of intra-abdominal fat, allowing a combination with the free fatty acid hypothesis, mentioned above. In the background of endocrine disturbances, there may be a neuroendocrine aberration, which at present is poorly understood.

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Annex 3

MEASURING SKINFOLDS AND CIRCUMFERENCES

The methodology described here and in section 3 of the main report has been collated from participants' experiences and from Seidell (1). Advice on these questions is also given in a recent publication on anthropometric standardization (2).

General recommendations for performing skinfold measurements

It is strongly recommended that in every study thorough training should be given to the field workers who will be involved. This should be done before the start of the actual study and should include all the proposed measurements on people of various body builds (ranging from slim to somewhat obese). Repeated measurements of the anthropometric variables on each subject should be evaluated with the aim of reducing inter-observer and intra-observer variation as much as possible.

For the skinfold measurements, the following are needed.

- A caliper with readings up to at least 40 mm (the pressure of the caliper jaws should be calibrated; the surface area on the tip of the caliper must be sufficiently large, and the pressure should be 10 g/mm²). Harpenden and Holtain calipers are both useful.
- A marker pen (to be used on the subjects).

Skinfolds are measured on the right side of the body. It is recommended that the observer should be assisted by a person who records the values. The skinfold is picked up between the thumb and the forefinger and held while the caliper jaws are applied at exactly the described point. After the full pressure of the caliper jaws has been applied, the actual measurement is made at the time the readings start to stabilize (usually after two to three seconds). The values are recorded to the nearest millimetre.

Every skinfold is measured and recorded in triplicate as an average of the three readings (which means that the complete measurement is repeated twice, including picking up the skinfold).

If no reliable figure can be obtained, e.g. in the case of very obese subjects, this is noted together with the recorded values.

Circumferences

Circumferences are measured on subjects (in the standing position). A subject should be standing with weight evenly balanced on both feet and the feet about 25-30 cm apart. Subjects should be asked to breathe normally and, at the time of making the measurements, be asked to breathe out gently. This prevents them from contracting their muscles or from holding their breath.

For the measurements, the following are needed.

- A plastic tape measure, not elastic or metal (metal will feel cold in cold climates).
- A marker pen (to be used on the subjects).
- An elastic tape (for positioning the level of the circumference). This is a narrow string of silk-covered "hat" elastic rubber band, which is tied firmly enough to stay in position around the abdomen about the level of the umbilicus. It should not be too tight, and its function is to assist in defining the levels of the circumferences.

Measurements are made in duplicate.

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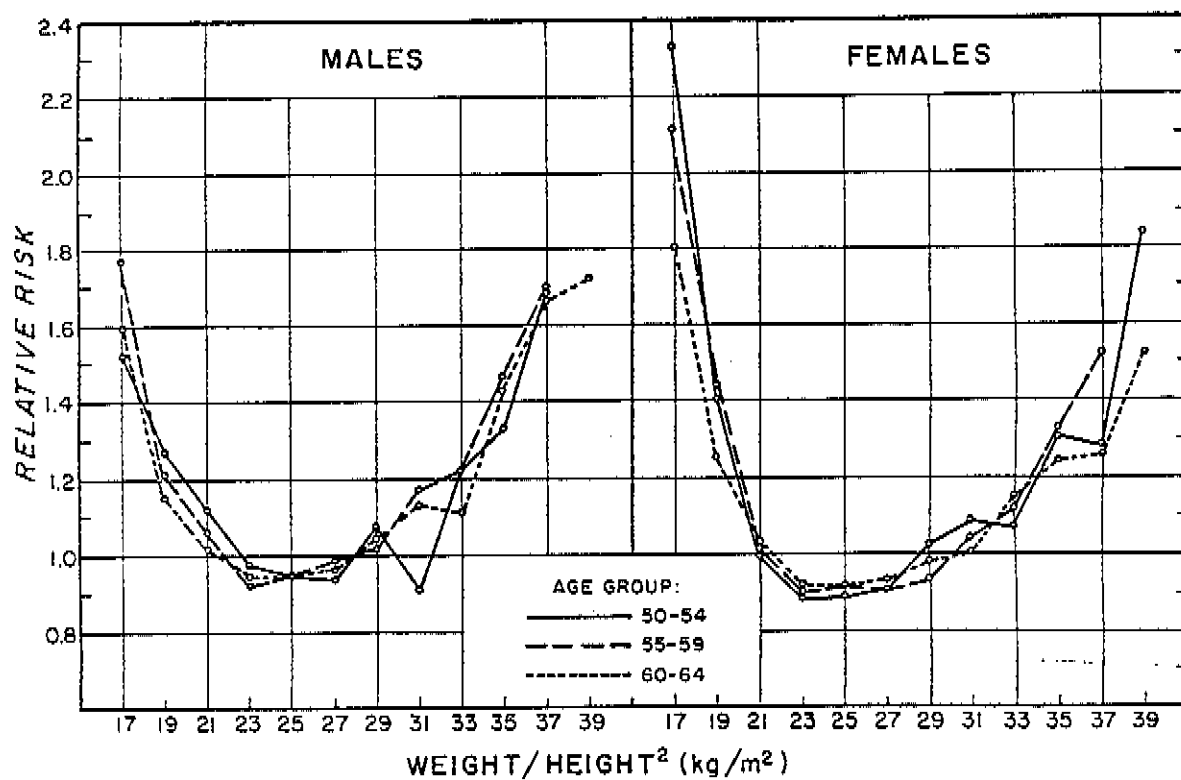
1. Seidell, J.C., Björntorp, P., Cigolini, M. & Deurenberg, P. Adipose tissue distribution: a multi-centre study. 1987 (unpublished manual of operations, prepared with the assistance of Oosterlee, A., Hoogkamer, R., Knuiman, J., Durnin, J.G.V.A., Sjöström, L., Rubeffé-Scrive, M. & Doornbos, G.).
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Annex 4

EPIDEMIOLOGICAL BACKGROUND

In the period 1963-1972, radiological surveys in Norway produced measurements on almost 2 million people over the age of 15 years. The response rate was 85-90%. These data were later followed up by identifying the end-point, i.e. mortality by cause. The presentation in Fig. 1 is thus based on 200 000 reported deaths and 18 million observation years. Some of the main findings are shown in this figure.

Fig. 1. Relative mortality for three age groups according to weight/height



Source: Waaler (1).

The relative risk curves are practically identical for the three age groups included in this presentation.

The U-shaped mortality risk curve according to the BMI is confirmed in this study. The U is asymmetrical, being steepest on the "lean" tail end. The curves are also characterized by an almost flat bottom, making the determination of the minimum very uncertain. The higher BMI values form a continuous slope, with no natural threshold value for definition of obesity.

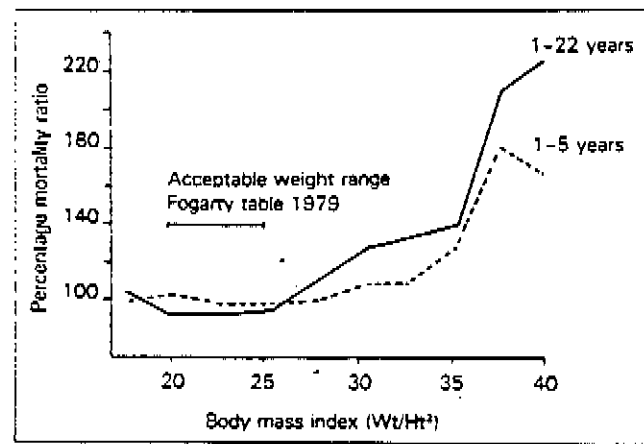
Other major studies of sufficient size and duration of follow-up for conclusions to be drawn are a study by the American Cancer Society (ACS) from 1979 and Build and Blood Pressure Studies from 1959 and 1979. The ACS study also allows more detailed analysis of the role of smoking in the relation between the BMI and mortality. A 1983 report by the Royal College of Physicians (2) shows mortality curves in relation to the BMI in these studies (Fig. 2 and 3). The Build and Blood Pressure Studies do not show an increased mortality in very lean people, due probably to the relatively small sample size ($n = 68\ 000$) whereas the ACS study with its much larger sample size ($n = 750\ 000$) confirms such an increase at the lower end of the BMI distribution. The larger the study, the clearer the health risks associated with leanness seem to become. No cause-specific deaths are presented here. Total mortality risk increases (as in the Norwegian study) slowly with rising BMI values, and the minimum mortality risk is somewhere between BMI 20-25. Smoking does not explain the higher risk in the left part of the U-shaped distribution curve (3).

As described in the Norwegian report, the left slope is dominated by lung-related disease mortality; the right slope (high BMI values) is dominated by mortality from cardiovascular disease, stroke and diabetes. Cardiovascular disease mortality increases in frequency from BMI 23 and upwards; lung diseases increase in frequency from BMI 29 and downwards. This mortality overlap complicates the definition of obesity.

There are no natural cut-off points; mortality is a continuous function of the BMI. If cut-off points are to be given for practical reasons, the classification proposed in this document might be reasonable.

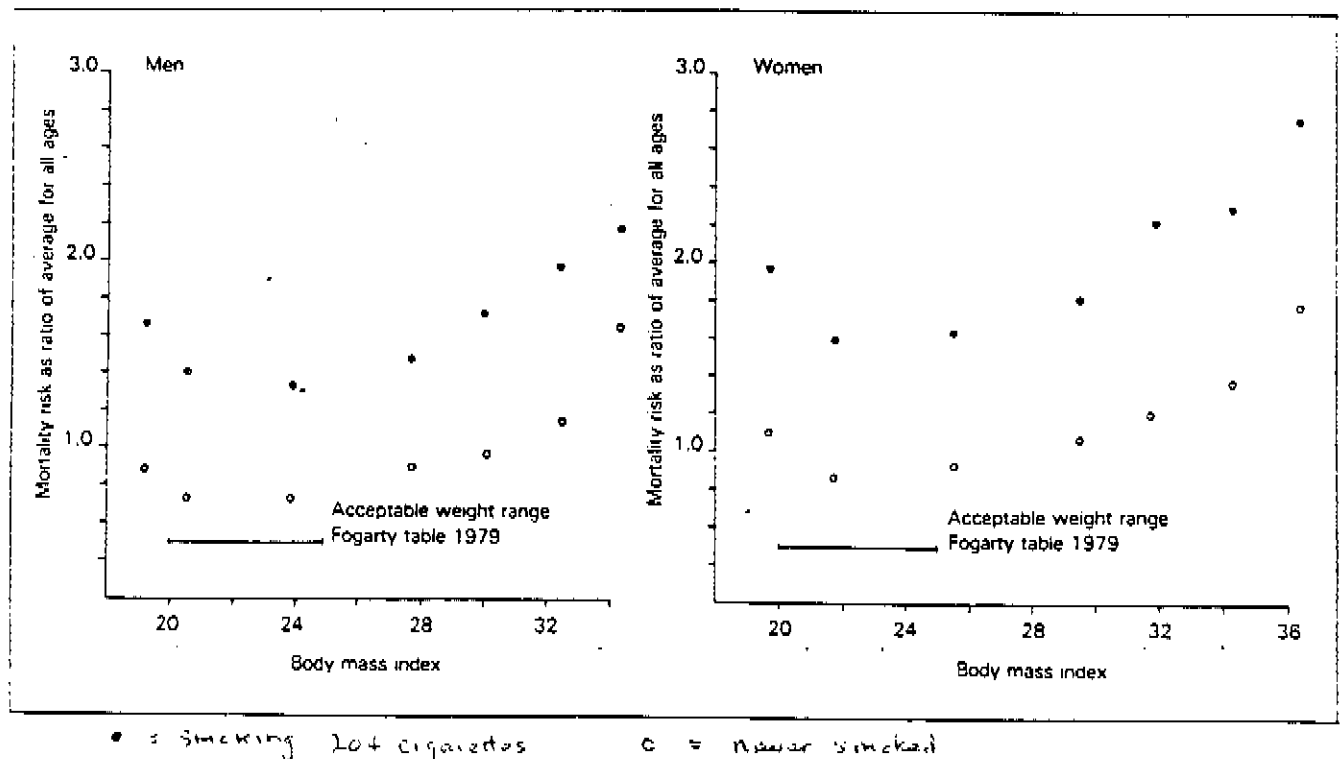
As a mere curiosity, it was demonstrated how the Broca index, which defines the optimum weight in kg as the body height in cm minus 100, appears to coincide with the level of mortality risk. Mortality was related to body height and weight in a simultaneous analysis, and relative risk was calculated for all combinations of height and weight. Out of this emerged a minimum-risk curve as a straight line connecting any given body height with an optimal weight (see Fig. 4). This line happens to be very close to the Broca index. However, the meeting was of the opinion that this index should not be recommended, since the values at the extremes of body height do not really correspond to the hypothetical values.

Fig. 2. Mortality in relation to duration of insurance policy - men aged 15-39 years at time of issue of policy (weight and height are adjusted to values without clothes)



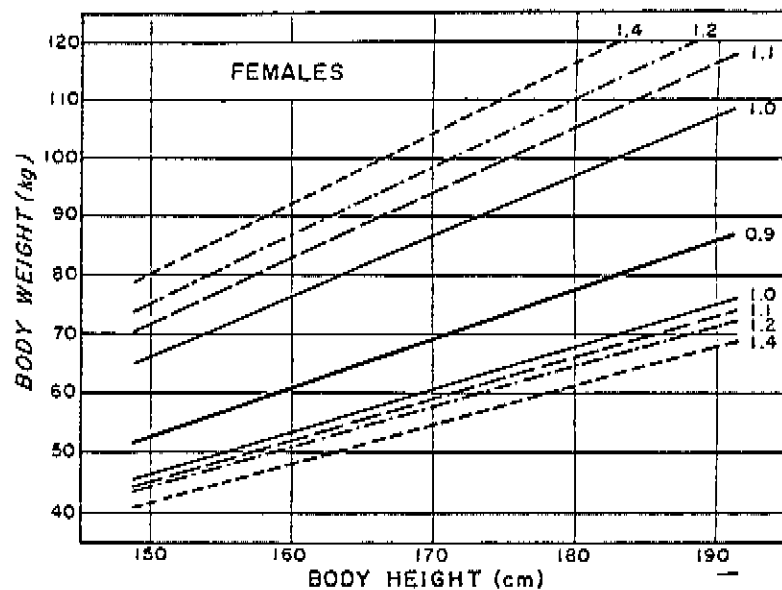
Source: Royal College of Physicians (2). Recalculated from the 1979 Build and Blood Pressure Studies.

Fig. 3. Body weight, smoking and death rates for men and women



Source: Royal College of Physicians (2). Recalculated from Lew & Garfinkel (3), with unpublished data from the American Cancer Society.

Fig. 4. Relative mortality by weight for given height in women



Source: Waaler (1).

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Annex 5

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