Age, sex and group specifics of physique and state of nutrition

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RÉSUMÉ

A partir de mesures anthropométriques sur la population de l'Allemagne de l'Est, de nouvelles valeurs standard pour le poids et la taille des hommes et des femmes, de l'enfance à la vieillesse, ainsi que des recommandations concernant la qualité de l'alimentation, ont été proposées.

Le développement corporel et l'alimentation des enfants et des adolescents ont été évalués en fonction de l'éducation des parents.

Il y a de grandes différences entre les enfants des employés et ceux des cadres. Chez l'adulte, on observe des différences de corpulence et d'alimentation entre les travailleurs stressés, ceux qui travaillent debout et ceux qui travaillent en position assise.

MOTS-CLÉS : Anthropometry, social differences, stature, height, weight, body-mass-index, index of obesity/state of nutrition, social differences.

1. INTRODUCTION

The measurements and proportions of our body are not only characteristically changing during the so-called growth age subject to our genotype but also the adult body does change in a sex-specific way according to its biological age. In addition to that, environmental factors take a modifying effect and thus increase the phenotypically variety on the basis of the individual genotype. Food is one of these most important modifying environmental factors. Everybody has to eat and to drink. His state of nutrition which results from the daily food energy intake, food energy metabolism and from his genetically fixed age- and sex-specific physique is correlated in a multivariated manner with his state of health. In this way an objective assessment of the state of nutrition allows conclusions to the state of health and is of epidemiological importance.

The basis of the assessment of the state of nutrition is generally the weight and its relation to height. As both signs develop in an age- and sex-specifics way also the proportions evaluated from them has to be evaluated according to age and sex. Simple proportions such as the BROCA-Index (normal weight = more than 1 meter height measured in cm) cannot be applied without doubt up to the youth age but they also often give wrong values in the adult age because they estimate too much weight as to be normal with increasing height. Tall persons of normal state of nutrition in this way are estimated as to be underweight and normal nourished small persons as to be overweight. In addition to that, age-specifics and sex-specifics are not taken into consideration. The Body-Mass-Index (BMI = 10 x weight (g) / height $(cm)^2$) is a well-proved and international often used measurement for the assessment of the state of nutrition. Following BRAY and GARROW (following ERBERSDOBLER and WOLFRAM, 1992) for the adult age a BMI less than 20 is estimated as underweight, between 20 and 25 as optimal weight, between 25 and 30 as overweight and more than 30 as obesity. Age- and sex-specifics of the state of nutrition here are not taken into consideration. Beyond that, diagnostics "obesity" can never be made only on the basis of an index out of height and weight. Differentiating the BMI according to age and sex so it allows an objective assessment of the state of nutrition from birth to senescy. Correlations between the genetical founded type of body shape and the state of nutrition but also between social groups and their state of nutrition can be estimated in an objective and reproducible way by right statistical grouping. Using the anthropocentric well analyzed East German

population, this paper demonstrates how the BMI can be applied as a suitable measurement for the estimation of the state of nutrition for all age groups and both sexes.

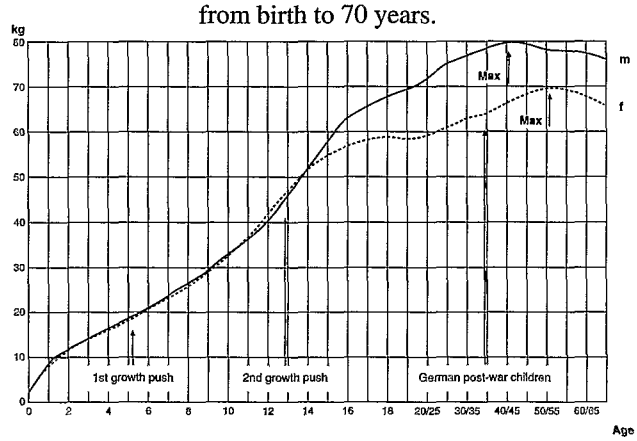
2. TEST PERSONS AND METHODS OF INVESTIGATION

A representative sample of 3,525 men and 3,387 women, aged between 18 and 70 years, was anthropometrically investigated from 1982 to 1984 as a basis of an anthropological data atlas (FLÜGEL, GREIL, SOMMER, 1986). This atlas is a tool for the design of industrial products, in accordance with the physical needs of men, and gives a detailed overview concerning standard values and ranges of variability of measurements of men and other physic signs. This sample was stratified according to sex, age, federal state and/or district and size of the settlement in proportion to the population of the ex-GDR. For the assessment of the social status, amongst others, profession and bodily stress at occupation were recorded (GREIL, 1988). 108 measurements and a lot of social and health criterions were taken from each test person, and the representativity was determined to 95% of statistical security.

After this, as of 1987, and in the same way, representative sample out of the East German population was taken from birth to the 19th birthday. It followed a reduced program of investigation of 32 measurements and a number of social signs out of the investigation program for adults. The reason of this reduced anthropometrical program was the fact that only such measurements could be involved which are measurable already at newborn age. The stratification again was made according to sex, age, geographical location and size of the settlement. The parental level of education, the number of siblings, and the stay at creche, kindergarten or after-school care centres were recorded as social indications.

To realize the same level of representativity as with the adult sample 18,123 male and 18,004 female test persons had to be investigated. It could be shown that there was no secular trend in physique between 1984 and 1987 because the 19th year of age was taken into consideration with both samples. This was the precondition for the statistical linkage of both samples. So an unique anthropometrical data basis for the whole age from birth to senescy was developed. It allows the investigation of many theoretical and practice-related problems of human biology and is also a proper basis for the analysis of age- and sex-specific specialities of the state of nutrition. Naturally the results gained from the East German population cannot be uncritically generalized. To get an useful instrument for the assessment of the state of nutrition, the BMI has to be newly adjusted with any other population. However, the characteristic picture of the sex-specific growth change gathered with one population concerning such a large age range should be valid quite generally.

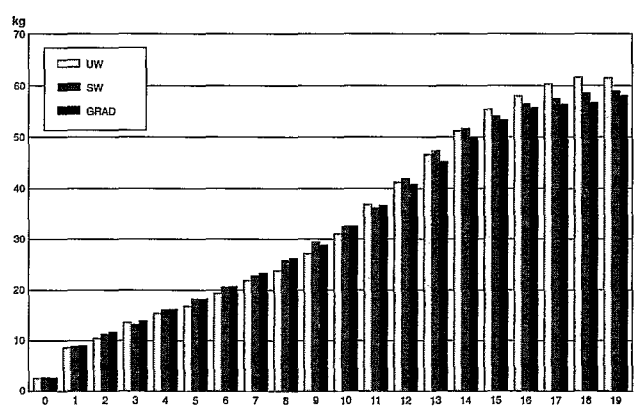
Fig. 1.
Mean values of weight with males and females from birth to 70 years.



3. STANDARD VALUES, RANGES OF VARIABILITY AND GROUP SPECIFICS OF WEIGHT

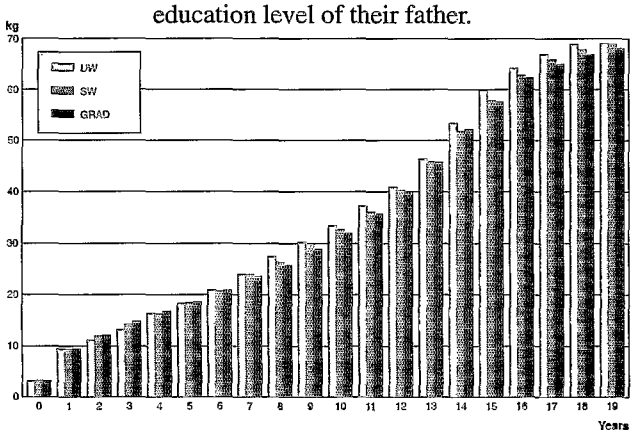
Surely, weight is the mostly investigated measurement. Birth weight is determined directly after birth. Its increase during the first months and years of life is observed as an indicator of a normal bodily development. With healthy persons generally the interest in their own body weight is decreasing during the subsequent years. Weight is only observed again in mature age when it increases more than before even if the bodily development of all length dimensions is finalized. Fig. 1 shows the average sex-specific weight from birth to senescy. On an average boys are born with a birth weight of 3,300 g. Girls have a 100 g less birth weight. This sex-specific difference is observed for many generations. Since the beginning

Fig. 2.
Mean values of weight with boys in dependence of the education level of their father.



UW = father unskilled worker, SW = father skilled worker, GRAD = father graduated.

Fig. 3.
Mean values of weight with girls in dependence of the education level of their father.



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of our century the birth weight of both sexes has clearly increased because of the secular trend. In East Germany a peak was reached in the mid-seventies. Today birth weight in the sense of a beginning secular deceleration is here some lower than 15 or 20 years ago. Comparing the generations only children of 3 years and more as well as youth and adults are more heavy on an average than in the past.

In the course of ontogenesis the weight of newborns increases after a short period of adaptation to the extra-uterine environment as strong as never again during their further life. At the same time its variability increases enormously. At 3 years the 3% of boys with the highest weight *e.g.* weight 7 kg more than the 3% with the lowest weight. In this correlation the variability of weight stays more or less normal distributed during the first 3 years of life. Only at the end of infant age an increasing scewness of the distribution begins. Now the differences between medium-weighted and heavy persons become considerably larger than those between light- and medium-weighted ones. The limits of the weight development are without doubt more open to the top than towards the bottom. This trend increases during ontogenesis and is most distinct with women during their mature age.

Comparing the sexes, girls and women normally have less weight than boys and men of the same age. Exceptions of this are given by the sex-specific higher speed of development with girls during their growth-pushes at the change from infancy to early school age and at the beginning of puberty. Here, at the same time, an enforced increase of weight and longitudinal growth pushes can be observed. These are the times of an accelerated bodily development which are known as the first and second change of body shape.

After the conclusion of the longitudinal growth, weight increases during decades.

The highest average values are reached with men at about 45 years and with women at about 55 years. Towards senescy and during this period weight generally decreases. The form of fat distribution also changes, in particular with the male sex, again in direction to a normal distribution. The reason for this could be the lower life expectance of strongly overweighted men. The today mature persons, born during the famine years at the end of the Second World War and during the first post war time, do not have a lower weight than earlier cohorts. Their deficit of food at early infancy was completely compensated.

In the GDR again and again was said that in the socialist system all people have the same chances of development. Group-specific specialities of the bodily development which could have been of interest considering the aspect of health care were rarely investigated or their results were not published if they did not agree with the ruling ideology. Therefore in this paper is investigated, as an example of possible influences of the bodily development by social factors, whether the level of education of the father, which is used as an indicator, has a modifying influence on the bodily development of his children, and especially on their state of nutrition. With all investigated signs, we distinguished between the educational levels of unskilled workers (UW), skilled workers (SW) and graduates of technical colleges or universities (T/U). Young fathers who were still studying were counted to the last group.

Fig. 2 shows from birth to 19 years the average values of weight with children and youth of different father groups. During babyhood and early infancy, about up to the beginning of the first change of body shape, a slight trend towards a some higher weight exists with sons of fathers with a high

Fig. 4.
Mean values of height with males and females from birth to 70 years.

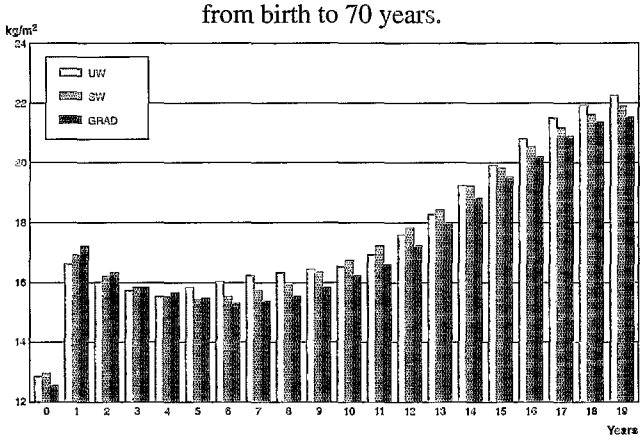
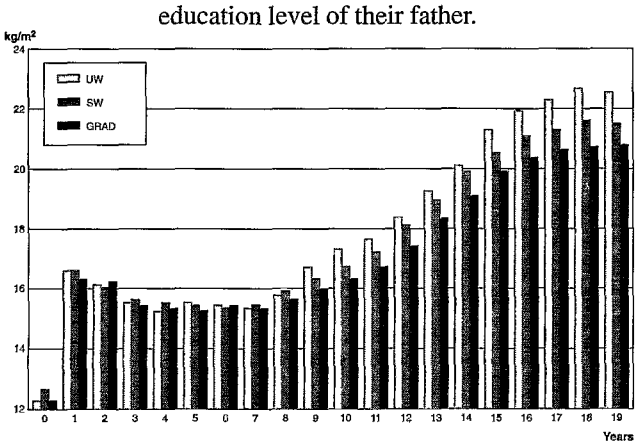


Fig. 5.
Mean values of height with boys in dependence of the education level of their father.



UW = father unskilled worker, SW = father skilled worker, GRAD = father graduated.

level of education. The lowest average values are observed with sons of fathers with the lowest level of education.

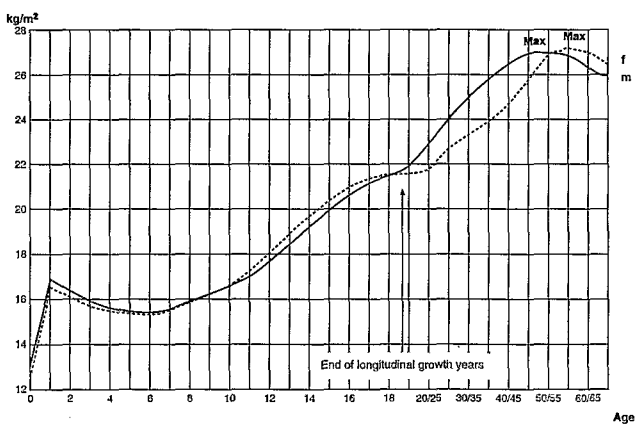
At the beginning of the school age there is a reverse of this relation. More and more the sons of unskilled workers increase in weight whereas the children of graduates become relatively light. The weight of girls show a very similar picture. Also here daughters of unskilled workers are at first in comparison to the other social groups relatively low-weighted. Later they have the relatively highest weight compared with the now clearly lighter daughters of graduated fathers. In a characteristic manner the reverse of the weight relations takes place with females somewhat later than with males. The educational level of the mothers has the same effect on the development of children's weight as that one of the fathers. Mothers in the GDR normally also had full-time jobs. There were no considerable numerical differences in the frequency of the educational levels between fathers and mothers. Also with a grouping according to the educational level of the parents, the results remained very similar. There was no possibility to determine the occupations of the parents with adult test persons. Therefore a new indicator for the social grouping had to be found which could be asked for.

Useful was a grouping according to the physical stress in occupation. This was asked following the rules of industrial medicine. There were formed a group of heavy work, a group of work in standing and/or walking positions, and a group of work in mainly sitting positions. There are hardly differences in weight between the groups with men. Only workers in sitting positions with an average weight of 76.1 kg are 300 g lighter than heavy workers older men in occupations with standing and walking positions. In difference to men physically high stressed women with an average weight of 66.9 kg are 3.0 kg heavier than women in occupations with standing and sitting positions and 3.5 kg heavier than women in occupations with mainly sitting positions. It seems that with women which are much lighter in weight compared with men, a long lasting physical stress requires a certain minimum of weight.

4. STANDARD VALUES, RANGES OF VARIABILITY AND GROUPS SPECIFICS AT HEIGHT

Height besides weight is an essential measurement for the assessment of the bodily development. Since 1975 the average values of birth length and of height in East Germany during the first two years of life became somewhat lower as the sign of a beginning secular deceleration (KÜHNEL and SOMMER, 1988). Newborn boys in 1990 had a birth length of 51 cm. Girls had 1 cm less. At the end of early infancy a reverse to a positive secular trend also here is observed. Comparing the generations elderly children, adolescents and adults

Fig. 6.
Mean values of height with girls in dependence of the education level of their father.



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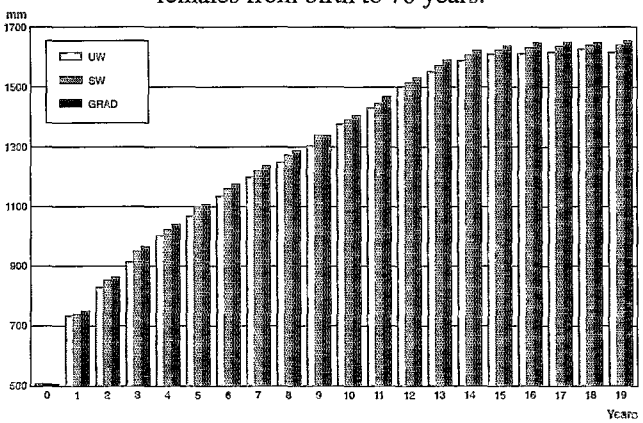
are now as before taller than in the past. The increase in height is during the first years of life in the same way the highest as that of weight. The final height is reached subject to sex with females on an average at about 18 to 19 years and with males at 21 to 23 years. After this the epiphyseal cartilages of the spine are not yet closed completely but height as a whole does no more increase. Comparing the sexes, boys are normally somewhat taller than girls of the same age. Again the ontogenetically higher speed of girls is shown. They reach the two longitudinal growth pushes on an average earlier than boys. Therefore they are comparatively taller during these phases of development. The typical sexual dimorphism of height develops only because of the earlier end of the longitudinal growth with females. Obviously it is genetically fixed and amounts to about 7% with all populations investigated in this

Fig. 7.
Mean values of the Body-Mass-Index with males and females from birth to 70 years.

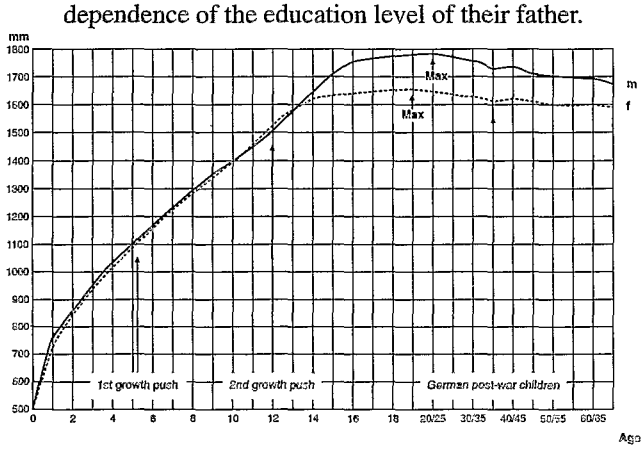


respect, *i.e.* related to men females of the same population have on an average 7% less in height. The low mean values of the about forty years old adults in Fig. 4 attract attention.

Considering the time of the anthroprometrical investigations (1982-1984) we see again the so-called German post-war children. Here the consequences of malnourishment during the stormy growth in early infancy are obviously not compensated up to the end of longitudinal growth.

The average values of height with boys are shown in Fig. 5 in dependence of the educational level of their fathers as it is shown in Fig. 2 for weight. In contrast to the relations in weight, in height there is a more and more increasing trend towards larger values with sons of graduated fathers from the beginning. These are the same tall sons who become the lightest during later infancy and adolescence. More height with lower weight means that we have relatively high and slender

Fig. 8.
Mean values of the Body-Mass-Index with boys in dependence of the education level of their father.



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children and youth. In opposite to this sons of fathers with a lower educational level often show a lower and more stumpy type of body shape. This is the same with females. Fig. 6 shows already at birth relatively low heights with daughters of fathers with a lower educational level and higher height values with daughters of graduates. The educational level of the mother affects also height in the same way than that of the father. At adult age, heavy workers of both sexes with on an average 173.3 cm with men and 161.8 cm with women are somewhat smaller than employed persons in occupations with standing and walking positions and they are clearly smaller than those in occupations with sitting positions. Men in occupations with standing and walking positions have a mean height of 174.2 cm and women of 162.0 cm.

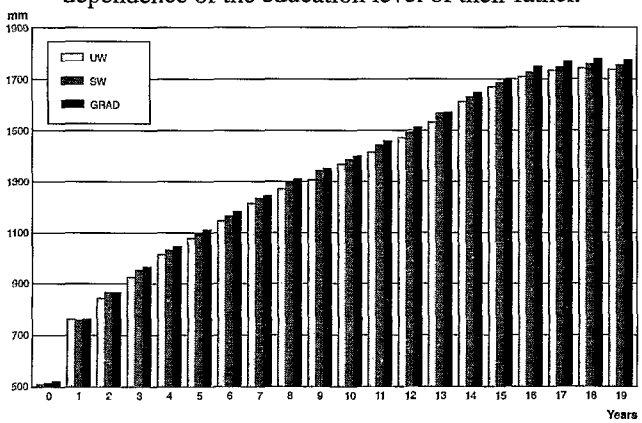
In typical occupations with sitting positions we have 175.1 cm with men and 162.7 cm with women. These are the mean values of the whole range of adult age from 18 up to 70 years. Young men are on an average 178 cm tall and young women a little more than 166 cm.

5. BODY-MASS-INDEX AND INDEX OF OBESITY AS MEASUREMENTS OF THE STATE OF NUTRITION

Statements concerning the state of nutrition can be made only to the height-related weight. A well-proved measurement for the assessment of the state of nutrition which is also recommended by the World Health Organization is the Body-Mass-Index (BMI). It is a quotient out of weight and the square of height. As the body during the first years of life grows intensively in all directions, as shown in Fig. 7, the BMI increases enormously at this time. The moment around the first birthday characterizes the roly-poly physique at the end of babyhood. Already at the beginning of the second year of life connected with a changed kind of locomotion a stretching of the body and a decrease of the BMI begins. The deepest values of BMI with both sexes are reached during early school age after the end of the first change of body shape. After this, an increase of the BMI takes place up to maturity. The same values as at the end of the first year of life are reached again at about 11 years.

From the beginning of puberty up to the end of the longitudinal growth, girls compared with boys have on an average a higher BMI. Then, in the same way as in weight, a sex-specific stagnation can be observed. After this, up to maturity the values of females are lower than those of males. This shows that a determination of the state of nutrition by means of BMI has to be effected not only age-specific but also sex-specific. Such a differentiation is not made by the wide spread standard values of BRAY and GARROW (following ERBERSDOBLER and WOLFRAM, 1993). In this way, elderly persons, especially men, often are estimated as to be overweight. Also KNUSSMANN (1988) does not give sex-specific values for

Fig. 9.
Mean values of the Body-Mass-Index with girls in dependence of the education level of their father.



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the Body-Mass-Index. Here an age- and sex-specific calibration of the standard tables would be useful. Additionally a consideration of the type of body shape should be made, *e.g.* following the well-tried method of CONRAD (1963) which is applied by JOHNSEN and SCHOLZ (1989) or following the statistically more demanding procedure of HEATH and CARTER (1967).

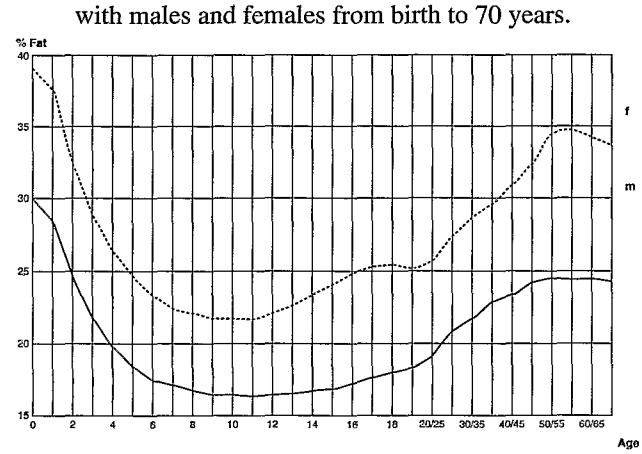
Subject to the educational level of their father sons (Fig. 8) and daughters (Fig. 9) show clearly different mean values of the BMI. While during early infancy sons of unskilled workers show at first a relatively low BMI, around the 5th birthday, that means at the time of the first change of body shape, a clear change takes place.

From now onward, the BMI with sons of graduated fathers is the lowest *i.e.* they have the most slender body shape while sons of unskilled workers become more and more corpulent. There are many reasons for this fact. One of these are most probably different dietary habits in the families. The fathers with a low educational level are on an average just those who are physically stressed at their occupation and heavy workers with a mean value of 25.4 BMI points have a high Body-Mass-Index. In comparison to this, workers in occupations with sitting positions have a Body-Mass-Index of only 24.8 BMI points.

With females, these differences between the groups are even more higher. During the whole growth age, the BMI of daughters of graduated fathers and/or parents and their state of nutrition is changing less. In opposite to this, daughters of unskilled workers start with a low BMI, but from the beginning of prepuberty they have distinct high BMI values. They show a clear tendency towards corpulence. Also here, adult females show with this grouping between heavy workers and workers in occupations with sitting positions with a difference of 2.6 BMI points higher differences than men. With men, this difference is only 0.6 BMI points. Altogether the variability of corpulence with females is more developed than with males.

If using the Index of Obesity (ABDEL-MALEK, 1985) instead of the Body-Mass-Index, this becomes understandable. This index, which in a multivariated manner was also developed on the basis of weight and height, estimates the percentage of total body fat of weight. Investigations on the thickness of the subcutaneous fat layer and on the densitometrically determined body composition prove its usefulness. It is observed that the female body compared with the male one during the whole life span has a characteristic higher share of total body fat. Also the variability of the Index of Obesity is clearly higher with females. The body shape of girls and women is much more characterized by fat than that of boys and men (BÖWE and BÖWE, 1993; GREIL, 1988; 1993). It would be a mistake to interprete these relations which are genetically fixed during many generations as an effect of chronic overnourishment. This is one of the reasons to underline once again that an assessment of the state of nutrition should be made not only age-specifically but also sex-specifically.

Fig. 10.
Mean values of the Index of Obesity with males and females from birth to 70 years.



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