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PRELIMINARY RESULTS OF A STUDY ON CHANGES IN GROWTH OF GIRLS FROM BREMERHAVEN

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Abstract: *The present results are basesd on data collected in two cross-sectional studies on growth and development, the 1. and 2. Bremerhaven Growth Study, which have been carried out in Bremerhaven in 1979/80 (n = 2796) and 1989 (n = 2170). The heights and weights of 10 to 17 year old girls are presented by half year age groups. While for height up to the age of 14.5 years there was only a slight, consistent but statistically not significant, tendency towards an increase over the last 10 years, increase in weight by age was considerable, amounting to 2.5 kg per age group on average. By means of Mann-Whitney-U-test these differences proved to be significant in almost all age groups. These changes in growth are also reflected by an increase of the index of weight for height. They parallel a decrease of mean age at menarche by 0.3 years / decade.*

Key words: *Secular changes; Growth and development; Height; Weight; Menarche; Germany.*

Introduction

For the western parts of Germany there are no recent data on the current state of secular changes in growth and development of children. Data from other European countries as well as from the eastern parts of Germany indicate that although some common features emerge there are some differences between European populations which are worth to be mentioned.

Material and Methods

The present results are based on data which have been collected in two cross-sectional studies with equal design of growth and development of girls from Bremerhaven, the 1. and 2. Bremerhaven Growth Study, carried out in 1979/80 and 1989. Bremerhaven is a city with almost 130 000 inhabitants, located in the northwestern part of Germany. Besides height and weight, which are discussed in the present paper, biacromial and biiliocristal diameters as well as skinfold thicknesses at triceps and subscapular were measured in both studies, furthermore data on menarche were collected. In 1989 sitting height was also measured. Due to the problem to be analyzed with the 1979/80 data, sampling was restricted to girls aged 10 to 16 years. Representative samples of girls of the respective age groups can be obtained in schools from pupils of the 5th to the 10th grades. In Bremerhaven in total there are 13 schools in which these grades are met with. In both studies we asked all girls to participate. Thus from the statistical point of view we are dealing with the population not with a sample and hence there should be no bias due to different sampling frames. In total the present results are based on data from 4966 girls, that is about 70% of the girls of the respective age groups.

The exact decimal age was estimated for each girl from her date of birth and the date of investigation using the table of decimal years (Healy et al. 1981). The age structure of the samples, with the age displayed being the midpoint of the underlying interval, is shown in *Table 1*.

Table 1. **Age structure of the samples**

Age [years]	1979/80		1989	
	n	%	n	%
10.0	16	0.6	9	0.4
10.5	76	2.7	70	3.2
11.0	153	5.5	124	5.7
11.5	195	7.0	185	8.5
12.0	229	8.2	185	8.5
12.5	266	9.5	192	8.9
13.0	243	8.7	177	8.2
13.5	213	7.6	186	8.6
14.0	238	8.5	161	7.4
14.5	251	9.0	169	7.8
15.0	262	9.4	194	8.9
15.5	267	9.5	184	8.5
16.0	215	7.7	161	7.4
16.5	104	3.7	90	4.1
17.0	46	1.6	56	2.6
≥17.25	22	0.8	27	1.2
Total	2796	100.0	2170	100.0

All statistical analyses which comprise estimation of descriptive statistics such as means, standard deviations and centiles as well as statistical tests like the Kolmogorov–Smirnov-test of goodness of fit of the empirical data to the normal distribution model, a parametric *t*-test of significant differences between means and the Mann–Whitney–U-test as nonparametric equivalent (where the assumption of an underlying normal distribution is not met) were performed using SAS software (1990).

Results

The means, standard deviations and centiles of height by age for the two studies are shown in *Figure 1*. Since Kolmogorov–Smirnov-test (for sample sizes less than 51 Shapiro–Wilk's statistic was computed) reveals that except for age groups 11.0 and 16.5 it seems reasonable to asume that we are dealing with a normally distributed trait, mean and standard deviation unequivocally characterize the whole distribution of the trait.

From *Figure 1* it emerges that there is a slight, but consistent tendency of increase in mean *height* from age 11.0 up to 14.5 years over the last decade. The difference ranges between 0.52 cm for girls aged 12.5 years to almost 2 cm in age groups 13.0 and 11.5, respectively. The latter two were the only differences which by means of t-test proved to be significant ($p < 0.01$). To test the significance of the differences t-test or – where there are deviations from the normal distribution model – the nonparametric Mann–Whitney–U-test was performed. The results for girls aged 14.5 years and older indicate that there is no consistent trend in differences of mean heights between the two surveys. The significant negative shift in age goups 10.5 and 17.0 seems to be due to chance, since these age groups include comparatively small numbers of girls which underlines sample size effects on descriptive parameters. The following discussion therefore focusses on results for age groups 11.0 to 16.5. Secular changes in the dis-

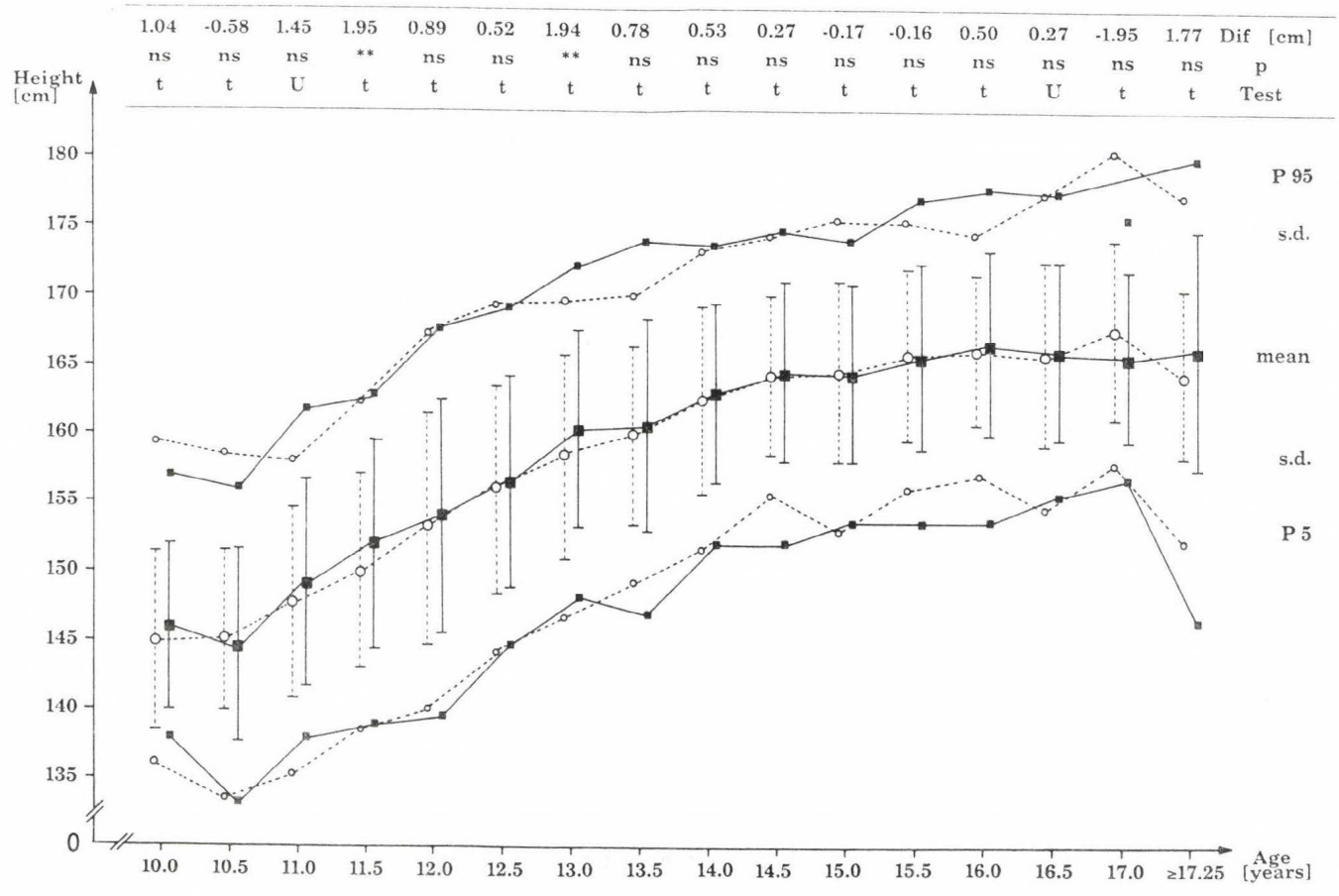

Fig. 1: Mean heights: 1979/80 survey (- - - **O** - - -) and 1989 survey (——■——)
First row: Differences between means in cm; — second row: Significance level of differences: ns: $p > 0.05$, *: $p \leq 0.05$, **: $p \leq 0.01$, ***: ≤ 0.001;
— third row: t indicates that *t*-test and U that Mann–Whitney–U-test was used

tribution of height cannot only affect the location of the distribution, as indicated by different means, but also its shape, which in normally distributed traits is defined by the standard deviation. At a first glance the results show no considerable differences in standard deviations. This is confirmed by the results of the corresponding *F*-test. Except for age groups 13.5 and 16.0 *F*-test reveals homogeneity of variances. For these two age groups the *t*-test statistic for unequal variances was computed. A further approach to analyse secular changes is to look at the centiles. While P_5 shows no regular pattern of variation, the values for P_{95}, except for age group 15.0, more or less show an increase.

Summarizing the results it is noted that in the lower age groups there is a consistent but with two exceptions statistically not significant tendency towards an increase in mean height whereas there are no unequivocal changes in the higher age groups.

The results for *weight* by age are presented by centiles because Kolmogorov–Smirnov-test and Shapiro–Wilk's-test, respectively, revealed that the empirical data of weight do not fit to the normal distribution assumption, at least not in both data sets simultaneously; the only exceptions are age groups 10.5, 13.5 and 16.5. The medians, P_5 and P_{95} of weight by age are shown in *Figure 2*.

The medians of body weight show a marked positiv change over the last decade. The differences between the medians vary from + 0.8 kg to + 4.8 kg. Averaged over the whole age range increase in weight amounts to 2.5 kg per age group. For girls aged 12.0 to 13.5 years increase in mean height is higher as compared to the older girls (except for age group 16.5). In the younger age groups we also find parallel, but not so evident positives changes in body height. Due to the deviations from the normal distribution model the significance of the differences was tested by means of Mann–Whitney–U-test, in all but the three age groups mentioned above. Except for the two lowest and highest age groups – where sample sizes are comparatively small – corresponding tests lead to statistically significant results, in five age groups even at the 0.1% level. The changing pattern in the distribution of weight is also reflected by P_5 and P_{95}. While except for girls aged 12.5 to 13.5 P_5 values show a tendency which – with regard to the magnitude – parallels the differences between the medians, P_{95} values show a considerable increase over the whole age range. The maximum difference amounts to 12.4 kg in 15.0 year old girls.

Summarizing the results for weight there is a marked increase in centiles during the last decade over the whole age range. In the younger age groups increase in weight parallels an increase in height, while from the age of 14.5 years onwards girls gained more weight without being taller. The marked changes in median weight and P_{95} might reflect an increase of the number of overweight girls, which would correspond to Eveleth's and Tanner's observation who in their 1990 edition of "Worldwide Variation of Human Growth" state that in European populations there seems to be a greater difference in weight than reported in the previous edition. Eveleth and Tanner (1990) conclude that there might be a higher prevalence of overweight and obesity in some populations.

So far we dealt with secular changes in size but what about changes in shape? Although there might be different approaches to the problem, we have chosen an age-specific index of weight for height calculated on the basis of individual data [weight (kg) * 10 / height (cm)]. This index relates the two variables linearly.

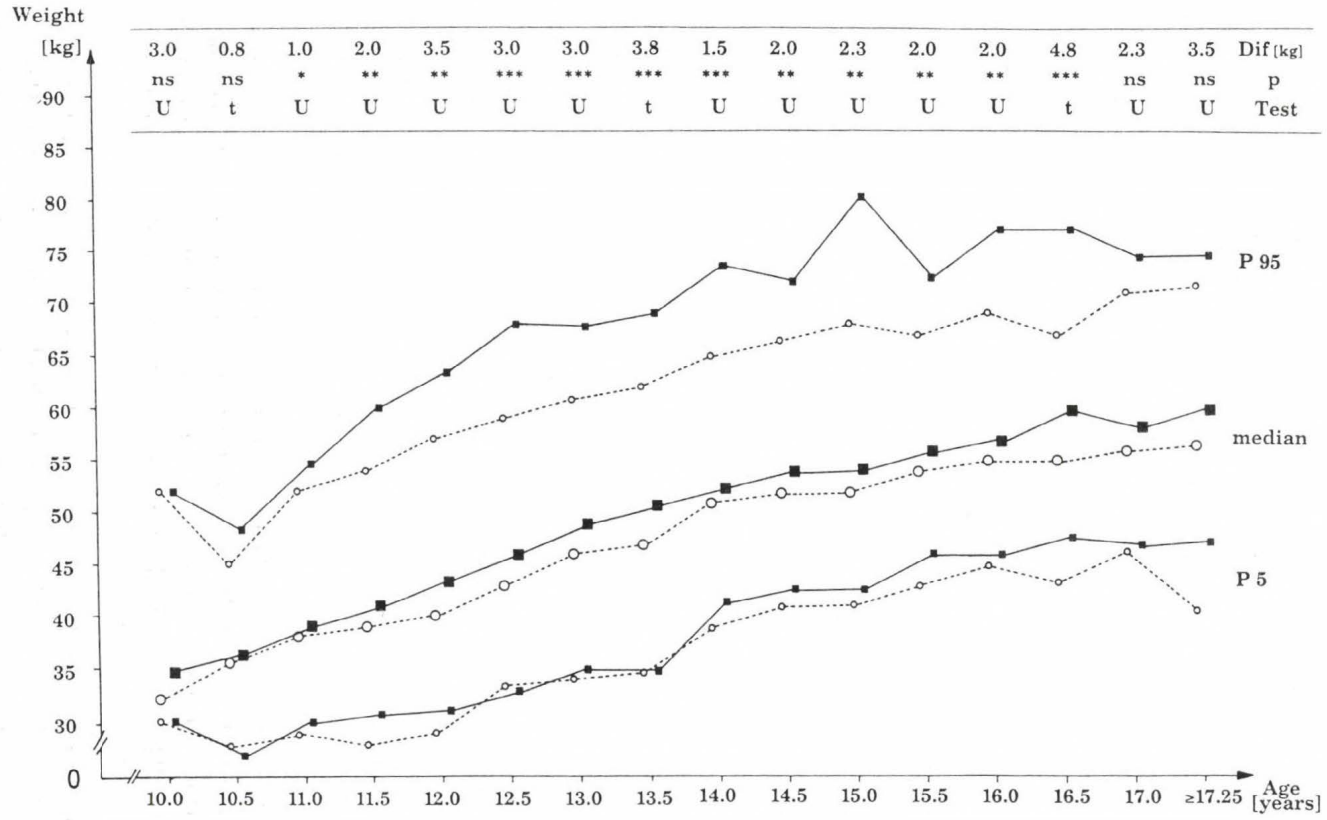

Fig. 2: Centiles of weight: 1979/80 survey (- - - **O** - - -) and 1989 survey (——■——)
First row: Differences between means in kg; — second row: Significance level of differences: ns: $p > 0.05$, *: $p \leq 0.05$, **: $p \leq 0.01$, ***: ≤ 0.001; — third row: t indicates that *t*-test and U that Mann–Whitney–U-test was used

Since the results of Kolmogorov–Smirnov-test and Shapiro–Wilk-test, respectively, reveal that – as for weight – we are dealing with a trait which seemingly is not normally distributed again centiles are presented instead of means and standard deviations. The centiles of the index of height for weight by age – as shown in *Figure 3* – exhibit the same tendency as those for weight. The differences between the medians are striking and proved to be significant for girls aged between 11.0 and 16.5 years by means of the Mann–Whitney–U-test and *t*-test, respectively; for six age groups even at the 0.1% level. The tendencies of differences in P_5 and P_{95} equal those observed for weight.

These observations thus reflect that the marked changes in weight are not only due to changes in height – not even in the lower age groups – but there is a considerable change in body shape over the last decade. The large differences between the medians of the index of weight for height in the higher age groups underline an increase of weight even in those age groups where mean height obviously did not change over the last decade.

Discussion

Summarizing the results on secular changes in growth and development of an urban sample of girls from northwest Germany it is noted:

1. The differences in height – which have been observed during puberty but not beyond the age of 14.5 – reflect changes in tempo of growth but not in size. Further evidence for tempo effects is provided by data on menarche. Probit analyses revealed mean ages at menarche of 13.30 years for 1979/80 survey and of 13.01 years for the 1989 one. The difference, which amounts to 0.29 years, by means of the *t*-test proved to be highly significant: $t_{(5017)} > 8.25$, $p < 0.001$ (Ostersehlt and Danker-Hopfe 1991). The changing pattern in age at menarche is primarily reflected by increasing proportions of postmenarcheal girls in the lower age groups. So it seems reasonable to assume that the differences in height during puberty – and to a certain extent those in weight – are due to tempo effects.

2. According to Danker-Hopfe and Finke (1991) females in north-west Germany reach adult stature around the age of 16 years. On the basis of combined data for girls aged 15.5 years and older mean heights revealed to be 166.1 cm in the 1979/80 survey and 166.3 cm in the 1989 survey. This leads to our second conclusion that there is no trend in mean height of young adult females.

3. For weight it is quite difficult to distinguish between size and tempo effects since due to nutritional influences weight changes or might change throughout life. This also is reflected in our data where even from age sixteen onwards, where mean height remains fairly unchanged, mean weight by age steadily increases. In contrast to height, secular changes in weight, are not only reflected in a shift of the location of the distribution but also in its shape.

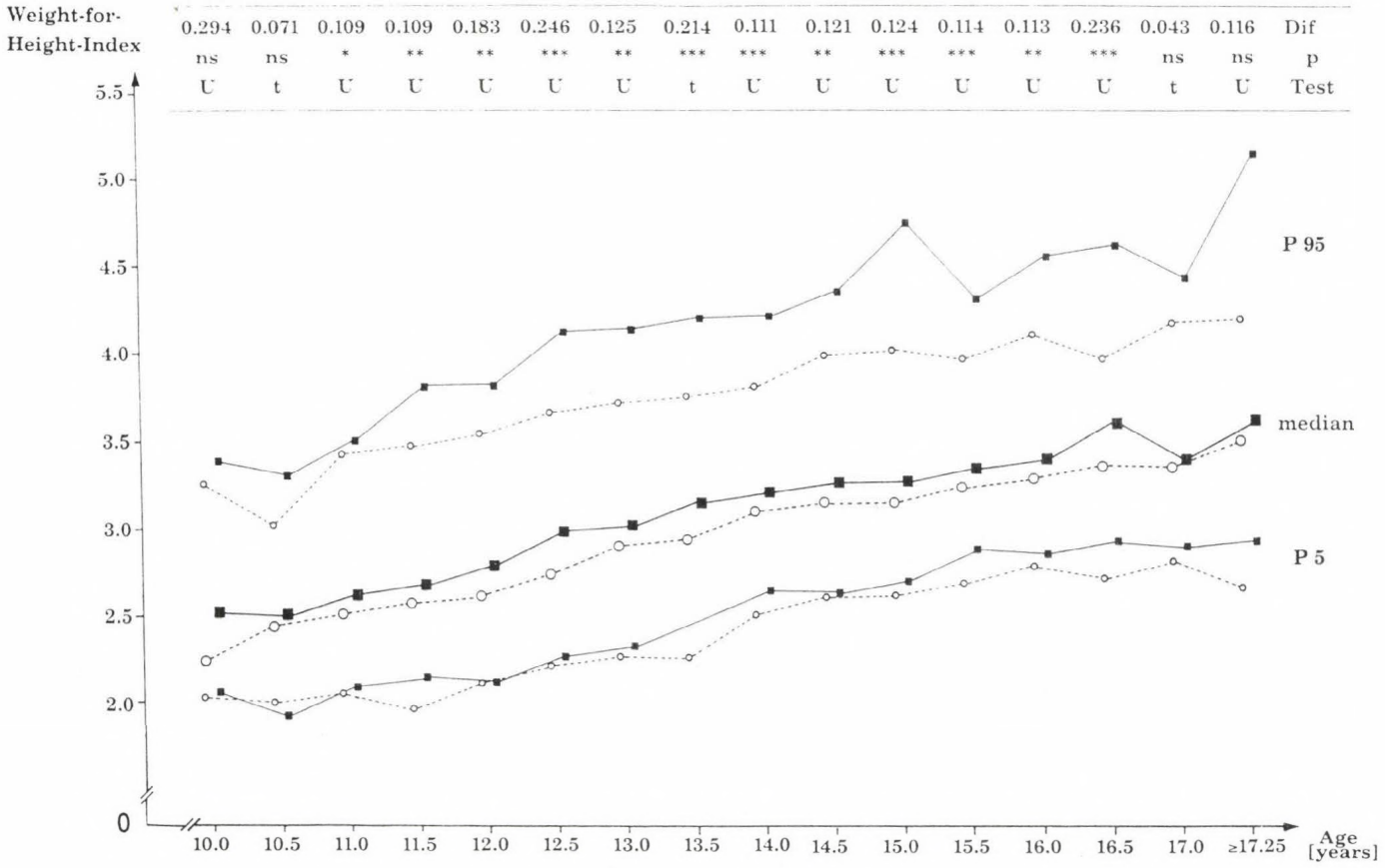

Fig. 3: Centiles of weight-for-height-index: 1979/80 survey (- - - **O** - - -) and 1989 survey (——■——)
First row: Differences between means; — second row: Significance level of differences: ns: $p > 0.05$, *: $p \leq 0.05$, **: $p \leq 0.01$, ***: ≤ 0.001;
— third row: t indicates that *t*-test and U that Mann–Whitney–U-test was used

4. Changes in body shape – which already emerge from the discussion of the different patterns of changes for height and weight growth separately – are confirmed by the data of weight for height index. In contrast to the thinning down, which often is associated with secular changes in growth and development of children (see e.g. Vercauteren et al. 1984 and Prebeg 1984), Bremerhaven girls show an inverse tendency. There is only one study showing results similar to the present ones. Lindgren and Hauspie (1989) reported a slight positive secular change in mean height for Swedish schoolgirls aged between 10 and 15 years while there is a marked increase in body weight over the whole age range.

It would be interesting to analyse to what extent the present results reflect an increasing prevalence of overweight. This aspect will be analyzed in the near future taking into account different definitions of overweight.

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