Anthrop. Anz. 69/2, pp. 159–174
J. Biol. Clinic. Anthrop.
published online February 2012

Notes

Diversity in auxology: between theory and practice

Proceedings of the 18th Aschauer Soiree, 13th November 2010

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DOI: 10.1127/0003-5548/2012/0133 0003-5548/12/0133 $ 4.00

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With 4 figures and 4 tables

Summary: Auxology has developed from mere describing child and adolescent growth into a vivid and interdisciplinary research area encompassing human biologists, physicians, social scientists, economists and biostatisticians. The meeting illustrated the diversity in auxology, with the various social, medical, biological and biostatistical aspects in studies on child growth and development.

Key words: child growth, adolescent growth, child development, height, weight, body mass, socio-economic environment.

Diversity in auxology

In the last years, auxology has greatly broadened its scope. International growth standards for height, weight, and body mass are being developed; they are used in assessing health and nutrition and have been found essential for documenting and controlling measures against the global epidemic of obesity. Auxological parameters are being used in quantifying the effects of the socio-economic environment on human biology. But in spite of its wide-spread practical use, still numerous theoretical aspects of auxology remain to be addressed. The present workshop summarizes both the diversity in auxological practice, and some new theoretical approaches in the understanding of child growth and development.

Under the premise that child growth is a sensitive indicator of overall health of the community, and in view of at least 200 million children who globally are not achieving their full development potential, Leslie Sue Lieberman discussed approaches for identifying underlying and proximate causes of physical, mental, social and environmental health and well-being (Social Determinants of Health, such as food supply, housing, economic and social relationships, transportation, education, and health care) (WHO 2008) and presented Mobilizing for Action through Planning and Partnerships (MAPP). MAPP is a community-driven strategic planning process for improving community health. Facilitated by public health leaders, it helps communities apply strategic thinking to prioritize public health issues and identify resources to address them (NACCHO 2004)

Vanessa Schönfeld Janewa, Arnab Ghosh and Christiane Scheffler compared growth in 497 boys, and 451 girls from Calcutta, India, and 528 boys and 618 girls from Brandenburg, Germany. The results of both cross-sectional studies indicate that

Calcutta children show peak height velocity at similar ages, but are significantly shorter, and have more body fat measured in skin folds and calculated by Slaughter et al. (1988) at all ages than the German children and adolescents (Tables 1 and 2).

Barry Bogin discussed characteristics of the human growth curve (Fig. 1). The stage of infancy (I) lasts from birth to age 30–36 months and is characterized by breast feeding, with complimentary foods added by age 6–9 months. The transition to childhood (C) by about age 3.0 years is characterized by the termination of maternal lactation, eating of soft and nutrient dense foods, and the completion of deciduous tooth eruption. The juvenile stage (J) spans age 7.0 years to onset of the adolescent growth spurt at approximately age 10 for healthy girls and age 12 for boys. Juvenile mammals are sexually immature, but physically and mentally capable of providing for much of their own food and care. Near the end of the juvenile stage, sexual maturation begins and one measurable effect is the adolescent growth spurt. The period

Table 1a. Height in boys from Calcutta, India, and from Brandenburg, Germany. Shaded areas indicate the higher values.

age	n		mean (cm)		*p*	SD	
	Calcutta	Brandenburg	Calcutta	Brandenburg		Calcutta	Brandenburg
9	3	126	131.13	138.98		7.85	7.01
10	36	117	137.58	143.29	< 0.001	6.36	6.78
11	54	86	142.36	149.66	< 0.001	8.64	6.91
12	92	82	146.93	157.27	< 0.001	9.34	8.95
13	61	43	152.82	162.73	< 0.001	9.34	9.64
14	86	21	158.17	171.42	< 0.001	7.92	9.47
15	61	15	161.34	175.33	< 0.001	6.61	8.85
16	50	13	163.36	177.38	< 0.001	8.37	6.95
17	26	6	163.15	177.07	< 0.01	8.04	6.21
18	25	14	164.00	176.40	< 0.001	5.43	9.32
19	3	5	163.00	180.48	< 0.05	3.36	9.11

Table 1b. Height in girls from Calcutta, India, and from Brandenburg, Germany. Shaded areas indicate the higher values.

age	n		mean (cm)		*p*	SD	
	Calcutta	Brandenburg	Calcutta	Brandenburg		Calcutta	Brandenburg
8	9	124	127.66	132.60	< 0.05	5.84	6.04
9	23	119	131.90	139.29	< 0.001	6.74	7.11
10	52	108	138.03	143.67	< 0.001	7.13	6.45
11	48	106	145.45	150.10	< 0.001	7.82	7.18
12	66	64	149.63	158.10	< 0.001	6.28	7.24
13	51	37	150.73	163.66	< 0.001	6.64	7.54
14	64	23	152.93	164.29	< 0.001	5.75	5.49
15	59	11	152.49	166.32	< 0.001	5.80	5.58
16	36	8	151.75	162.40	< 0.001	4.41	6.15
17	23	7	154.07	169.03	< 0.001	6.56	5.87
18	18	8	151.63	169.15	< 0.001	4.48	9.82

Table 2a. Body fat in boys from Calcutta, India, and from Brandenburg, Germany. Shaded areas indicate the higher values.

age	n		mean (cm)		*p*	SD	
	Calcutta	Branden-burg	Calcutta	Branden-burg		Calcutta	Branden-burg
9	3	126	26.53	18.29		11.76	8.73
10	36	117	26.95	17.92	< 0.001	10.76	7.72
11	54	86	28.51	20.56	< 0.001	10.85	9.91
12	92	82	26.90	18.02	< 0.001	10.33	9.36
13	61	43	26.88	18.47	< 0.001	9.82	7.29
14	86	21	24.38	17.93	< 0.05	11.86	7.49
15	61	15	23.22	17.18	< 0.05	9.87	6.38
16	50	13	21.33	17.50		9.62	9.48
17	26	6	21.10	14.26		11.58	2.97
18	25	14	18.39	16.86		8.68	6.88
19	3	5	21.52	20.45		5.84	2.50

Table 2b. Body fat in girls from Calcutta, India, and from Brandenburg, Germany. Shaded areas indicate the higher values.

age	n		mean (cm)		*p*	SD	
	Calcutta	Branden-burg	Calcutta	Branden-burg		Calcutta	Branden-burg
8	9	124	19.87	16.92		7.95	6.10
9	23	119	22.35	18.73	< 0.05	7.75	6.95
10	52	108	26.97	20.53	< 0.001	9.16	7.76
11	48	106	27.38	20.22	< 0.001	7.92	6.68
12	66	64	27.87	20.54	< 0.001	6.51	7.19
13	51	37	29.96	22.73	< 0.001	7.01	6.41
14	64	23	31.20	24.20	< 0.001	5.36	7.52
15	59	11	28.82	23.40	< 0.01	6.72	4.92
16	36	8	30.54	25.88	< 0.05	6.10	4.53
17	23	7	30.62	24.00		8.25	2.05
18	18	8	25.67	24.62		7.08	6.28

from beginning to end of the spurt is the adolescent stage (A). Adolescence ends with the eruption of the third molar (if present) and the termination of growth of the skeleton. Adulthood and reproductive maturity follow. Growth in height remains stable to age 30 years or so and then declines at about 1 cm per decade. Weight may increase for several decades, especially as fat accumulates, and then may decline in old age.

Elena Godina compared morphofunctional characteristics in two generations of 7 to 17-years-old children in the city of Arkhangelsk measured in 1988 (n = 1500) and 2010 (n = 1500). Height increased significantly in the present generation compared to the previous one. Thus, in 16-year-old boys the means are 171.82 cm (1988) and 173.68 cm (2010), and in 16-year-old girls, 161.75 cm and 163.18 cm correspondingly. In contrast to other observations on secular changes in height that mainly consisted of changes in the long bones, Arkhangelsk children instead showed an increase in rump length at all ages, whereas leg length tended to either decrease (girls) or remain unchanged (boys). The increase in weight is not so significant: in 16-year-old boys it

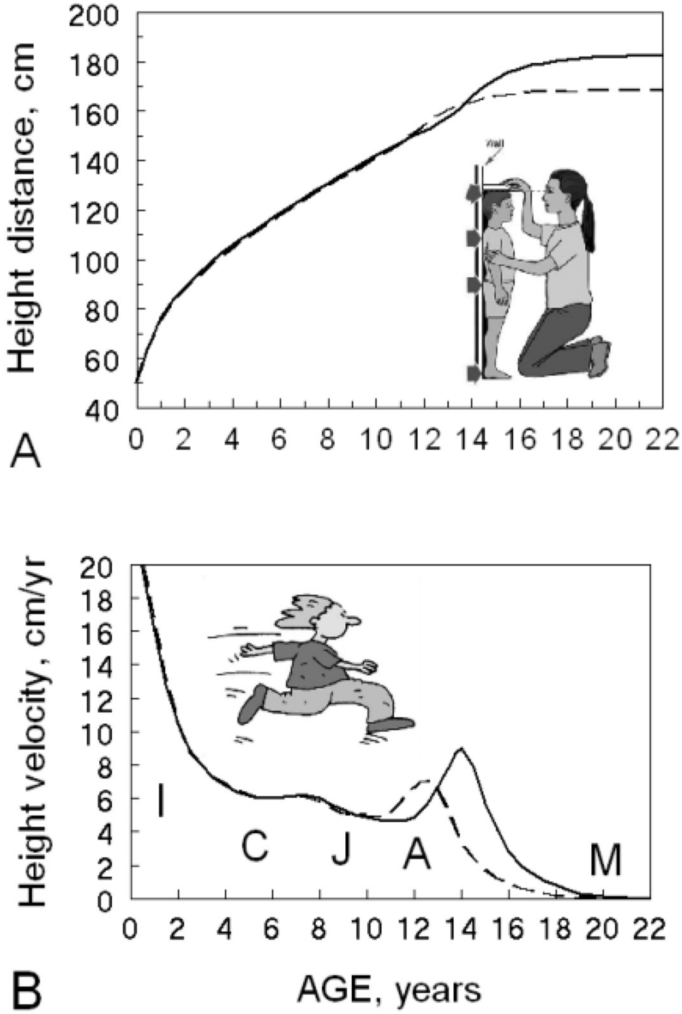

Fig. 1. The pattern of human growth in height from birth to adulthood (body weight follows very similar curves). The distance curve (part A) indicates the amount of height achieved at a given age. The velocity curve (part B) indicates the rate of growth at a given age. The velocity curve best illustrates the human postnatal growth stages of infancy (I), childhood (C), juvenile (J), and adolescence (A).

is 61.1 kg in 1988 and 61.9 kg in 2010. For the girls the picture is more complicated: for younger girls there is a slight increase in weight, while in the older ones weight remained stable or even decreased. For 16-year-old girls the corresponding figures are 56.4 kg and 55.65 kg. There are noticeable differences in skinfold distribution: subscapular and abdominal skinfolds increased in the last 2 decades.

Maria Kaczmarek identified social factors moderating the health of 13–19 years old adolescents, for targeting groups at high risk for poor health, in a cross sectional cohort survey in Wielkopolska voivodship 2008–2009. The sample consisted of

1997 girls and 2004 boys. Apart from medical examination of the adolescents, parental reports on daily life circumstances and chronic illnesses/conditions, and face to face YQOL interviews of the adolescents were evaluated. Obesity was associated with low economic wealth (OR = 2.71, 95 % CI 1.92:3.41), low social strata (OR = 2.64, 95 % CI 1.85:3.21) physical activity (OR = 3.98, 95 % CI 2.73:4.69), smoking (OR = 1.42, 95 % CI 1.13:2.49). Chronic disease was associated with low economic wealth (OR = 2.51, 95 % CI 2.01:2.96), low social strata (OR = 2.57, 95 % CI 2.23:3.26) physical activity (OR = 1.97, 95 % CI 1.42:2.53), and with smoking (OR = 2.93, 95 % CI 2.02:3.64). Regular smokers, both girls and boys, practicing sedentary life were more likely to have ill-health, irrespective of their SES than those physically active and who never smoked (OR = 1.9 and OR = 2.9)

Obesity is an important issue in Egypt with a prevalence among preparatory and secondary school children of 14.7 % in males and 15.1 % in females (Salem et al. 2002). Mortada El-Shabrawi presented clinical, ultrasonographic and biochemical predictors for Non Alcoholic Fatty Liver Disease (NAFLD) in a 76 obese Egyptian children aged 2–15 years. Sixteen patients (21 %) had elevated alanine aminotransferase (ALT) and 6 (7.9 %) had elevated aspartate aminotransferase (AST). Significant dyslipidemia (low HDL-C, high total cholesterol, high LDL-C and triglycerides) and higher insulin resistance were found in obese patients ($p < 0.01$). The main ultra sonographic findings were hepatomegaly in 20 patients (26.3 %) and echogenic liver in 41 patients (53.9 %). Liver biopsy showed simple steatosis in 8 patients (24.2 %) and nonalcoholic steatohepatitis in 7 (21.2 %). LDL-C was the only sensitive predictor (independent variable) for NAFLD in both uni- and multivariate logistic regression analysis.

Emad Salama reported on a cross sectional growth study in 5245 healthy subjects (2716 boys and 2529 girls) aged 1–16 years and representing about 12 % of all children from South Sinai. The population differs in ethnicity and in environmental, climatic, and social circumstances from other areas in Nile valley. Boys (2–5years) of the South Sinai have higher BMI values than the WHO values. Girls of the South Sinai have higher values in the second and third year of age, while WHO values are higher during the fourth and fifth years of age (Table 3).

Kaspar Staub, Frank Rühli and Ulrich Woitek presented two future research possibilities analyzing the anthropometric data from conscription in Switzerland 1875–2009. First, the body shape (relative average height, chest and arm circumference, weight and BMI) of particular occupational groups at both the lower and upper end of the socioeconomic strata was compared through soc. spider plots in 1875–79 and the 1930s. In 1875–79, 19-year-old students and commercial employees were rather tall with a high ratio between height and chest circumference and BMI, craftsmen and unskilled workers were rather small with low ratios. Unskilled workers had smallest average height, chest circumference, weight and BMI, students had among the highest values. Extremely high circumferences and BMI had the conscripts working in the food production (bakers, pastry cooks). In the 1930s, unskilled workers had higher average BMI values than the students. Apparently, not only social affiliation exerted strong influence on the physique through the living conditions, but also habitual and daily physical activity (occupation). Second, new and detailed instructions for medical inspection during conscription from 1932 also included a large catalogue of categories of diseases and aliments which lead to unfitness. On individual level, body measurements can be linked with information about struma and diseases, differentiated by socioeconomic background. Thereby, significant influences of struma or of rickets on height can be detected.

Table 3-1. Means and standard deviations of weight (kg) of Egyptian boys and girls in South Sinai.

Age	Boys (2716)			Girls 2529			*p*-value
	N	Mean (kg)	(SD)	N	Mean (kg)	(SD)	
1 year	135	9.45	2.19	126	8.89	2.06	0.034
2 years	96	12.15	2.53	76	11.14	1.97	0.004**
3 years	131	13.98	2.60	119	13.05	2.18	0.002**
4 years	146	15.29	2.27	106	15.21	3.06	0.800
5 years	121	17.60	2.92	130	17.25	3.02	0.351
6 years	215	19.98	3.63	180	19.54	3.57	0.224
7 years	250	22.05	3.24	244	21.89	4.47	0.653
8 years	265	24.33	4.44	216	24.07	5.07	0.545
9 years	210	27.02	6.17	246	27.26	6.21	0.687
10 years	230	30.53	7.25	240	30.73	7.67	0.769
11 years	177	32.41	7.29	229	34.87	8.21	0.002**
12 years	203	36.72	7.84	143	40.87	10.21	0.000**
13 years	147	42.73	13.10	106	44.60	12.41	0.252
14 years	120	49.33	13.97	118	49.85	11.37	0.752
15 years	124	53.40	11.36	102	52.09	8.89	0.341
16 years	146	58.81	12.81	148	55.97	10.90	0.041*

*$p < 0.05$ = significant difference
**$p < 0.001$ = highly significant difference

Table 3-2. Means and standard deviations of stature (cm) of Egyptian boys and girls in South Sinai.

Age	Boys (2716)			Girls 2529			*p*-value
	N	Mean (cm)	(SD)	N	Mean (cm)	(SD)	
1 year	135	73.75	5.79	126	73.45	5.62	0.673
2 years	96	85.03	4.73	76	83.26	6.07	0.033*
3 years	131	90.10	4.92	119	90.15	5.40	0.942
4 years	146	98.02	6.57	106	99.36	6.25	0.104
5 years	121	106.71	7.09	130	107.06	6.31	0.677
6 years	215	113.92	6.63	180	112.89	6.19	0.114
7 years	250	119.15	5.92	244	118.85	6.54	0.584
8 years	265	124.35	6.15	216	123.80	7.47	0.373
9 years	210	129.31	6.63	246	129.48	6.57	0.778
10 years	230	134.72	7.44	240	134.85	7.06	0.850
11 years	177	138.14	7.17	229	139.77	7.29	0.025*
12 years	203	144.05	7.20	143	145.66	8.25	0.054
13 years	147	149.61	9.53	106	149.96	6.90	0.747
14 years	120	157.58	9.83	118	152.86	7.37	0.000**
15 years	124	161.81	8.53	102	155.35	4.32	0.000**
16 years	146	166.25	9.40	148	157.43	6.77	0.000**

*$p < 0.05$ = significant difference
**$p < 0.001$ = highly significant difference

Table 3-3. Means and standard deviations of BMI (kg/m^2) of Egyptian boys and girls in South Sinai.

Age	Boys (2716)			Girls 2529			*p*-value
	N	Mean (kg/m^2)	(SD)	N	Mean (kg/m^2)	(SD)	
1 year	135	17.46	3.38	126	16.50	2.83	0.014*
2 years	96	16.82	2.63	76	16.05	2.24	0.046*
3 years	131	17.23	3.17	119	16.10	2.43	0.002*
4 years	146	15.87	1.80	106	15.34	2.21	0.038*
5 years	121	15.42	1.75	130	14.97	1.56	0.031*
6 years	215	15.32	1.57	180	15.26	1.70	0.698
7 years	250	15.46	1.34	244	15.40	2.13	0.712
8 years	265	15.64	1.87	216	15.59	2.11	0.785
9 years	210	16.04	2.55	246	16.17	2.75	0.599
10 years	230	16.70	3.05	240	16.79	3.50	0.776
11 years	177	16.85	2.81	229	17.67	2.96	0.005*
12 years	203	17.59	3.02	143	19.16	4.36	0.000**
13 years	147	18.83	4.10	106	19.71	4.57	0.108
14 years	120	19.60	4.47	118	21.26	4.36	0.004*
15 years	124	20.31	3.68	102	21.58	3.52	0.009*
16 years	146	21.23	4.25	148	22.62	4.46	0.007*

*$p < 0.05$ = significant difference
**$p < 0.001$ = highly significant difference

Pavel Blaha reported on cephalic dimensions. In modern 6 year old boys head circumference has reached 91.85 %, maximum length of the cranium 91.65 %, maximum width of the cranium 93.95 %, bizygion distance 94.67 %, and the morphological height of the face 80.47 % of the head dimensions of 17-year-old males. Six year old girls have reached 94.14 % in head circumference, 95.23 % in maximum length of cranium, 93.30 % in the maximum width of cranium, 91.76 % in the bizygion distance 94.67 %, and 84.95 % in the morphological height of the face compared with 17-year old young women. In the recent decades, the cephalic dimensions have changed with a significant debrachycephalisation (Zellner et al. 1998). In general, tall individuals show a lower cephalic index value. Debrachycephalization is also linked to the present secular trend of body height in the Belgian (Vercauteren et al. 1990)

Christian Aßmann presented a new Bayesian approach to growth modelling. Percentile crossing is a physiological phenomenon in child growth, and occurs at all stages with two thirds of all children crossing more than one standard deviation in height. In longitudinal height data from two large national growth studies (Zürich, Switzerland, 120 boys, 112 girls, with information on height, menarcheal age (girls), and Tanner stages on sexual maturation, and bone age; and Budapest, Hungary, 342 boys, 316 girls (provided by the courtesy of Dr. Kalman Joubert, 2010) with information on height, menarcheal age (girls), Tanner stages on sexual maturation), Aßmann provided preliminary evidence for an "adaptive backward looking mechanism" in adolescent growth. When modelling growth conditional on tempo, controlled via Tanner stages of puberty, adolescents appear to correct future height gains with respect to passed height gains: the taller the person at present in relation to his/her age mates, the smaller the consecutive growth rates.

Stef van Buuren presented a new method for estimating overweight prevalence from self-reported data. It is known that self-reports are systematically biased. The solutions proposed to date do not account for regression to the mean, and therefore lead to estimates that are systematically too low. The new method requires a calibration sample with both measured and self-reported data. The critical assumption is that the relation between measured and self-reported data in the calibration sample also holds in the sample of interest. Under this assumption, multiple imputation can be used to impute the unknown 'measured data' based on the known self-report data. The method yields unbiased estimates and valid standard errors of the 'true' overweight prevalence given the self-reported data.

Andreas Lehmann discussed the decrease in mean menarcheal age in recent history (Lehmann et al. 2010). This well known trend is usually explained by the advances in the health and wealth of people. Studies on menarche usually focus on mean values for menarcheal age, whereas analyses of the age distribution are missing. The Fig. 2a/b illustrates the similarity in the historic patterns of the mean and the standard deviation of menarcheal age in two very different ethnic groups: in German girls between 1848 and 2007 with r = 0.93, and in South Korean girls between 1925 and 1995 with r = 0.87. It appears that affluent societies are characterized by a narrow "biological baseline variance" of some 1 year^2, whereas poor circumstances appear to add an additional "socio-economic variance" that leads to a delay in the age of menarche.

Takashi Satake presented a body proportion chart (BPC) for summarizing growth of stature, sitting height and lower limb length in children and adolescents. Fig. 3 exemplifies the use of this chart initiating some new and quite unexpected visual impressions on patterns of individual growth.

Hans Henrik Thodberg presented an automatic method for bone age determination (www.BoneXpert.com). Bone age is most commonly determined by the Greulich Pyle method. Yet, the inter-rater variability is in practice high. The standard deviation between two ratings typically ranges from 0.62 years (Thodberg & Sävendahl 2010) to 1.16 years (Bull et al. 1999). The standard deviation between BoneXpert and a relatively reliable rater was found to be typically 0.72 years; part of this standard deviation is due to the human variability. The method is fast, gives identical interpretations of an X-ray, and satisfyingly agrees with manual bone age determination. The precision of bone age determination when this includes taking a new X-ray is 0.18 years. Being a new method of bone age assessment, it is crucial to ask: Does it really measure maturation? This is confirmed by a study (Thodberg et al. 2009) showing that adult height is predicted more accurately by the new automated bone age than by manual rating.

Eilin Jopp examined the final period of tibial growth in 41 healthy male subjects, aged 15.7 to 19.8 years, measured and weighed at weekly intervals over a period of 1 year. She determined the lower leg length using a hand-held knemometer (technical error 0.3 mm), and related growth with the state of maturity, measured by magnetic resonance tomography at the beginning and the end of the study. The subjects were divided into 3 groups according to maturity of the tibial growth plate (either open, or centrally fused, or completely fused). Whereas all subjects with open tibial growth plates significantly grew in the lower leg, significant lower leg shrinkage of –2.4 mm (SD 2.1 mm) was detected in subjects who showed fused tibial growth plate in the beginning of the observation period (Jopp et al. 2011).

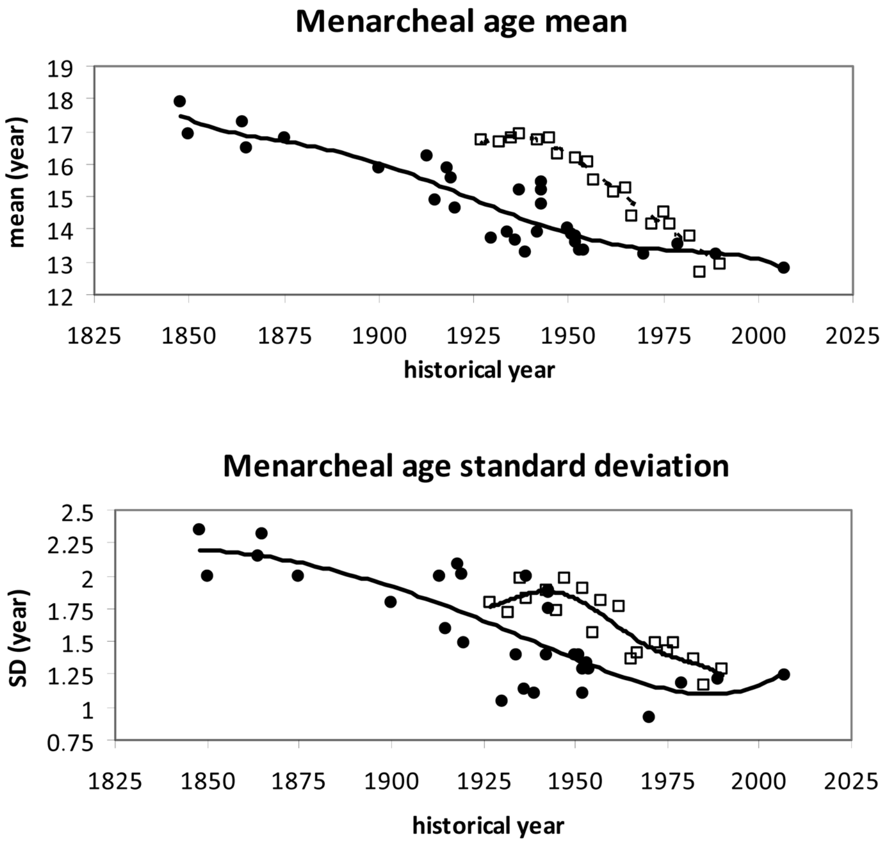

Fig. 2a/b illustrates the similarity in the historic patterns of the mean (top) and the standard deviation (SD) of menarcheal age (bottom) in German girls between 1848 and 2007 (r = 0.93), and in South Korean girls between 1925 and 1995 (r = 0.87). Affluent modern societies are characterized by narrow SD and a low mean menarcheal age.

Sylvia Kirchengast raised attention towards obesity in migrant populations. Increased prevalence of childhood obesity among special migrant populations (Table 4) is the result of a fast acculturation towards lifestyle, unhealthy behavior and cultural values of lower social strata in the host population. In future obesity research, obesity prevention strategies and obesity treatment the following points should be considered: Cultural differences in nutritional habits and health related behavior per se, the problem of acculturation and modernization towards unhealthy behavior of lower social strata, and the idea that migrants are still a population in transition (Kirchengast & Schober 2006a, b, Dijkshoorn et al. 2008).

Janina Tutkuviene discussed body size and body image during the puberty. 30–80% of girls and 20–40% of boys are unsatisfied with their own body size and shape. Gender differences exist in body image and self-esteem during the puberty: girls wish to have slender bodies; they are particularly unhappy with their thighs, hips and waist. Boys especially at the end of adolescence, prefer more massive bodies, and

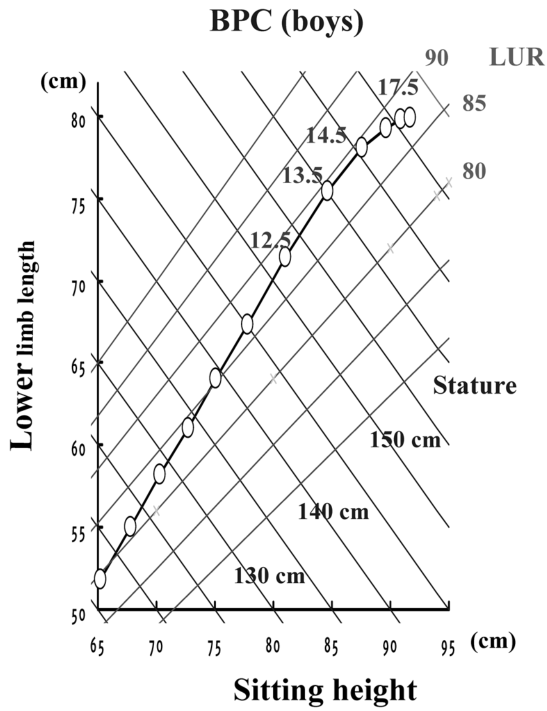

Fig. 3. Body proportion chart (BPC). Age change for Japanese boys are depicted. LUR means "lower body–upper body ratio".

mostly dislike shoulders, chest and extremities. Self-esteem in girls during the puberty strongly depends on body dissatisfaction. This was not the case in the boys. No significant relationship was found between the actual body size, body proportions and body satisfaction in both genders. Janina Tutkuviene particularly stressed the importance of promoting healthy body images (Thompson & Smolak 2008).

Matthew McIntyre discussed the relevance of the second-to-fourth digit ratio (2D:4D) as a biomarker reflecting prenatal androgen effects. Sex dimorphism in the 2D:4D ratio develops at young ages (Manning et al. 2004, McIntyre et al. 2006,

Table 4. Obesity among migrants in Europe.

Origin of immigrants	Immigrant		Host population		Country/ author
	male	female	male	female	
Turkish	11.7 %	24.1 %	8.3 %	14.1 %	Germany (Will et al. 2005)
Turkish	23.4 %	30.2 %	12.6 %	16.5 %	Netherlands (Fredriks et al. 2005)
Morocco	15.8 %	24.5 %			
Turkish/ northern Africa	20.0 %	24.0 %	19.0 %	20.0 %	Belgium (De Spiegelaere et al. 1998)
Turkish	20.6 %	20.3 %	18.4 %	17.8 %	Austria (Kirchengast & Schober 2006)

McIntyre et al. 2005) and has been associated with sex-linked traits in humans, and with mating systems in both living (Nelson & Shultz 2010) and extinct primates (Nelson et al. 2011). However, the between-person variation is large and poorly understood.

Ursula Wittwer-Backofen presented new approaches towards facial soft tissue reconstructions based on the skull bone. Virtual 3D- techniques will replace former plaster modelling as they allow modifications of facial surface and texture during the reconstruction procedure or afterwards. This is especially evident when forensic case studies face new hints during the identification process. Besides other, the available techniques were presented for a virtual facial reconstruction of the famous 16–20 year old bog girl called "Moora" (Bauerochse et al. 2008) and the exceptional finding of a nailed skull of a Dutch noble lady from the early 17^{th} century (Schlager et al. 2010). Soft tissue thickness data which derive from computed tomography of clinical patients can be used for calculations of the highest probability for a facial surface given age, sex and nutritional status and based on Geometric Morphometric algorithms. As well, this technique can be used to demonstrate changes in facial proportions during childhood and adolescence for numerous applications in auxology as well as for age morphing procedures in Forensic Anthropology which becomes especially evident in the age progression of missing children.

Jesper Boldsen analyzed the possibility for using data from ancient skeletons to reconstruct growth curves from past populations. He presented a model based on the so-called 'Osteological Paradox' (Wood et al. 1992) for the effect on selective mortality on height both among those who died before reaching adulthood and those who survived to adulthood. Selective mortality for (short) stature will create bias in cemetery samples of heights of children as these immature skeletons would represent those who did not survive to adulthood and thus be a shorter subsample of the once living cohorts of growing children. Based on the model it is predicted that there should be a height gap of 0.85 standard deviations (corresponding to approximately 6 cm) between those who died in childhood or adolescence and those who survived to adulthood. Fig. 4 gives a scatter plot of heights measured in 200 graves of the medieval cemetery of Tirup and age at death (for a description of the cemetery see e.g. Boldsen 2007 and for a description of the method of measuring height in the grave, see Boldsen 1984). In the figure skeletons without a sex determination (mostly children) are marked with filled triangles, male skeletons with open squares and female skeletons with open circles. There is clearly no gap between heights of immature and adult skeletons in this figure. This means that that there is no evidence for selective mortality for height in Medieval Denmark; and that it actually is possible to use these measurements to reconstruct ancient growth curves.

David Martin presented new data that give rise to the question as to whether the rise of DHEAS of the adrenarche around the age of 7 to 10 years is related to the psychological "falling out of the paradise of childhood" that children experience at this age and to which Rudolf Steiner thought teachers should pay particular attention. He also presented the riddle of the 7–11 effect: in the First Zurich Longitudinal Study the growth of metacarpal cortical thickness as measured by BoneXpert suddenly decelerates at the age of 7 years. The reason for this change in bone physiology – leading to an actual dip in the Pediatric Bone Index from the age of about 7 to 11 years – remains to be elucidated. Is it an endogenous sign that the child is ripe for a new phase in life? Or is it exogenously caused by the change in lifestyle incurred by

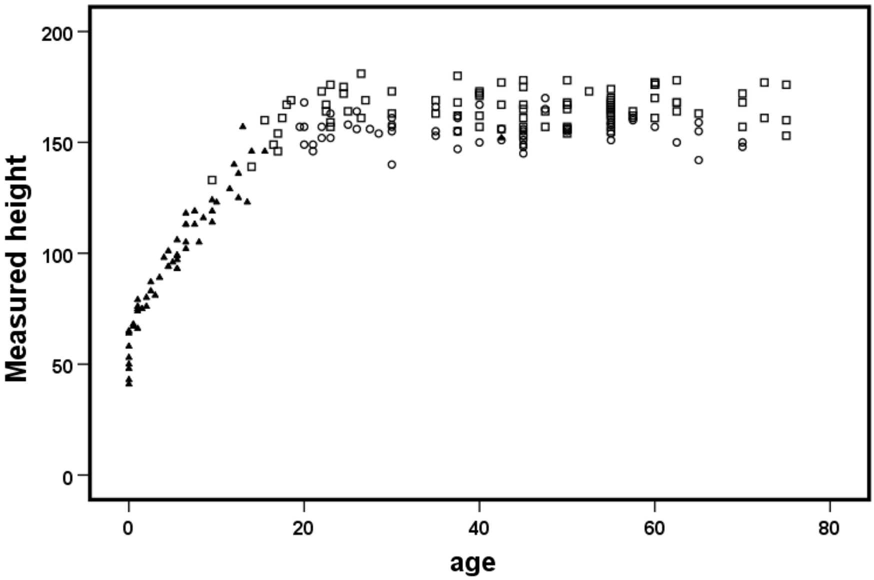

Fig. 4. Scatter plot of heights measured in 200 graves of the medieval cemetery of Tirup and age at death. In the figure skeletons without a sex determination (mostly children) are marked with filled triangles, male skeletons with open squares and female skeletons with open circles. There is clearly no gap between heights of immature and adult skeletons in this figure.

school entry? David Martin's Mechanography data from 868 children from Tübingen Kindergartens and the Tübingen Waldorf School showed that the age of about 6.5 years is also the time at which the children reach motoric maturity in terms of jumping skills.

Jürgen Meier discussed intellectual property (IP) rights that have gained more and more attention, not only in the competitive business environment, but also in academia and in governmental organizations and institutions. Such rights, which include patents, trademarks and designs, not only foster science and innovation, but finally lead to exclusive rights granted by the government to an inventor or originator for a fixed period of time. In exchange for this grant, the inventor must publicly disclose the invention. Commercial industries as well as research institutions try to protect their IP in order to safeguard and guarantee, at least to a certain extent, a return on their (in some cases tremendous) investment in research and development. This same strategy that applies to the pharmaceutical industry can be applied to the food industry. Patents can protect novel and innovative products for a period of 20 years and said protection can, inter alia, comprise the protection of "functional food". Here, protection in the form of technical right, like a patent, is possible, but trademarks are also very popular and important to this industry. There is, however, a narrow line between the protection of "functional food" and the protection of a "pharmaceutical". In this respect, not only do national and regional patent offices (like the European Patent Office) play a role in the grant of a commercial monopoly, but regulatory and marketing authorities may also be important players if a "food stuff" is classified as a "pharmaceutical".

The meeting ended with recommendations on dietary intake assessments presented. Leslie Sue Lieberman showed that methods and techniques should be age and gender appropriate for the respondents, they should be culturally sensitive and culturally tailored (format, food, items, pictures, presentations and recordings). Techniques for assessing the quantity of milk intake by breastfeeding infants was discussed (IFE Core Group 2008) as well as the use of appropriate food composition tables and standardized methods to calculate fiber, macronutrients, vitamins and minerals in complementary foods and those consumed by young children (Berdainer et al. 2007, MAMI Project 2010). Attention should be paid to foods, processing and preparation that could interfere with digestion, absorption and metabolism.

In summary, the meeting illustrated the broad and multidimensional interest in auxology, a discipline that has developed from mere describing child and adolescent growth into a vivid and interdisciplinary research area encompassing human biologist, physicians, economists and biostatisticians.

Acknowledgements

This work was supported by Deutsche Gesellschaft für Auxologie and by Norddeutsches Zentrum für Wachstumsforschung.

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Submitted: 2011-March-03;
accepted: 2011-June-19.

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