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AUXOLOGICAL EVALUATION

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Abstract: *Auxological evaluation, that is the set of operations leading to a determination of the normality or abnormality of growth, is nowadays a highly valuable tool in both epidemiological and clinical investigations. In epidemiological research the relationship between environmental pollution and growth is becoming more and more important. Auxological evaluations, besides being used in the diagnosis and prognosis of illnesses, are currently also used in the study of the aetiology of illnesses. The latter topic is a recent acquisition.*

Keywords: *Auxology; Human growth; Epidemiology; Bone age; Paediatric endocrinology.*

Introduction

By auxological evaluation we mean the set of operations leading to a determination of the normality or abnormality of growth and which reveal, more generally, the status and the dynamics of growth in epidemiological investigations, in clinical settings and in other situations dealing with a single individual.

Epidemiological investigations

Epidemiological investigations, which are generally conducted on samples of a population, may have one of the following goals: 1) mass screening for the early diagnosis of growth disturbances; 2) determining whether there is a relationship between a negative environmental factor (pollution, adverse socio-economic conditions, etc) and growth; 3) comparison of growth in different populations and in different periods (secular trend); 4) the study of growth in a population as an index of social and economic development.

The auxological characteristics taken into consideration are, in most investigations, anthropometric measurements, physiological events such as menarche; physical capabilities such as strength, speed, endurance, etc; functional characteristics; and components of the body.

In Humanbiologia Budapestensis 15 years or so ago we published the results of a mass screening conducted in all of the schools in an industrial area near Florence (Nicoletti and Colombo 1989). We had planned two levels of investigation: 1) the first regarded all of the students and comprised the measuring stature and weight as well as registering the date of birth, along with the gender, of course, and the stature of the parents, in order to calculate the target stature; 2) the second level was concerned only with those students for whom the first level had, on the basis of our own pre-established criteria, revealed the probable insurgence of a growth disorder.

We believe that this sort of two-level investigation is still effective. As it is well known, in a clinical context the conventional wisdom considers an individual with a

measurement corresponding to the 3rd centile potentially abnormal, all the more so if the figure falls below the 3rd centile. This is a judgement based on probability through comparison with a standard and may be formulated more or less as follows: "If the individual that I have examined exhibits a stature (or weight or other measurement or characteristic) corresponding to the 3rd centile I suspect that his/her stature is abnormal because in the reference population I have used to construct a standard only 3% have a stature equal or inferior to his/her". In mass screenings we suggest raising the limit distinguishing presumably healthy from potentially anomalous individuals to the 10th centile, in order to include – in the phase of the first level – the maximum number of individuals who may be subject to a growth disorder. The question becomes that of which standard to use: a stature $\leq 10^{th}$ centile but $> 3^{rd}$ centile calls for the calculation of the target stature and of the target range, which are indicative of the genetic background and are calculated on the basis of the stature of the parents following the usual procedure as presented in all manuals of auxology (cf. Nicoletti et al. 2004). If the stature of the individual examined fits a growth curve that falls within the target range one can presume that growth is normal.

For evaluations based on weight, the Body Mass Index is more and more widely applied, with Cole and colleagues' (2000) tables used to distinguish normal individuals from those who are overweight or obese (Nicoletti et al. 2004). One can specify in the program whether to proceed to the second level only with the obese or with the overweight children as well.

At the second level (with a paediatrician and an auxologist, whereas nurses are entrusted with the first level) a medical examination is accompanied by a detailed medical record, thorough anthropometric measurements and an examination of skeletal maturation. The second level leads to the formulation of a certain number of diagnoses (e.g. of delayed growth and maturation), so that only a limited number of individuals are sent to the hospital or to specialized centres for further examinations (endocrinological, genetic, etc). For the examination of skeletal maturation, at the second level one can apply a simplified method (cf. Nicoletti 1988).

In studies of the relationship between growth and environment, of the differences between populations and of secular trend, auxological evaluation is often based only on measurements of height or weight and, in girls, on the age of menarche; in some studies other measurements are collected as well, such as sitting height, certain circumferences, diameters, etc (on investigations of secular trend: Eiben 1994, Bodzsár and Susanne 1998, Tóth and Eiben 2004).

Studies of the relationship between growth and the environment have demonstrated, among other things, that within a single population, and consequently with no correlation with particular ethnic groups, the difference in stature between children belonging to high versus low social classes is pronounced and may reach, for example, 4 cm among 7-year-olds in Hong Kong and 12 cm among Indian children (cf. Rona 2004).

Striking theoretical implications and meaningful premises for social policy programs may be drawn from this sort of observation, based as it is upon the manipulation of data that are relatively easy to obtain as long as one follows standardized guidelines for their collection and applies the appropriate statistical methods.

Investigations concerned with a single individual

Clinical auxology

By this expression we mean the contribution of auxological evaluation to the diagnosis and prognosis of illnesses and to the study of the aetiology of illnesses. The latter topic is a recent acquisition. Rona writes, ".. [auxologists] focus on whether a disease or treatment of a disease has an effect on growth. However, growth and development can also be a causal factor in the chain of events leading to a disease; can be part of the condition, and consequence of the condition".

On the other hand, auxological evaluation in the clinic has contributed for many years to the diagnosis of illnesses and the prognosis of growth, and especially to research in, and the practice of, paediatrics, paediatric endocrinology, and childhood and adolescent gynaecology. In some situations, auxological evaluation assumes a key role in the definition of a syndrome and in its prognosis. We note, as an example, the results of some of our studies on central precocious puberty and early puberty in girls. These conditions are defined as the appearance of Tanner's stage 2 for both pubic hair and breasts before the age of 8 or between the age of 8 and 9, respectively, without organic causes and in the absence of pathological conditions such as congenital adrenal hyperplasia, hypothyroidism or growth hormone deficiency. The results (Nicoletti et al. 2001) indicate that the criterion whereby a girl entering puberty below the age of 8 is to be treated, and which is generally applied in clinical practice, must be replaced with a series of criteria capable of distinguishing more precisely those individuals to be given treatment in order that they achieve normal height. Four such auxological criteria have been distinguished: 1. skeletal maturity $\geq 80^{th}$ centile; 2. (height SDS – target height SDS) >1.0; 3. presence of height growth spurt; and 4. presence of skeletal maturation spurt; as well as two endocrine gynaecological criteria: 1. positive pubertal GnRH-test (LH peak ≥ 4 x baseline); 2. signs of development in ultrasound (transitional uterus and/or microcystic ovary). The conclusion we have reached is that when an acceleration of height growth and skeletal maturation is observed and the auxological and endocrine-gynaecological criteria mentioned above are satisfied, girls with precocious puberty as well as those with early puberty should be treated with LHRH analogue for a period varying from 12 to 48 months. Those girls with central precocious puberty who have entered puberty after five years of age and who did not satisfy the conditions mentioned above usually do not need treatment. Some of these girls, however, may at a later age meet the auxological/endocrine-gynaecological criteria mentioned above and therefore require treatment. For this reason biannual follow-up examinations are mandatory.

This example gives us the opportunity to note that auxology has highlighted the importance in the clinic of the analysis of the kinetics of growth: the velocity and acceleration of growth in stature and of skeletal maturation are often primary diagnostic and prognostic factors.

The study of the kinetics of growth requires the application of particular models, which have been developed in the last decades (cf. Milani 2000).

The evaluation of skeletal maturation, as is well known, may be performed following a variety of methods, some of which are especially widely used, but which must be adapted to the population to which they are applied (cf. Nicoletti 1988). This adaptation should be based on a random sample drawn from the population in question; however, it is only

rarely that the sample is selected randomly in auxological studies: the sample may be considered sufficiently random if the are no selective factors, factors, that is, which favour the inclusion of individuals with specific auxological characteristics. Our experience has shown that this adaptation is absolutely necessary in evaluating the skeletal maturation of individuals, who have just reached, or are about to reach, puberty. This is because various studies, including our own, have shown that the curves for stature of different populations (for example different European populations) tend to coincide in early and later childhood but to diversify with puberty.

Evaluations of skeletal maturity, as performed nowadays, vary strongly according to the person who makes them. This has led some to consider the possibility of automating the evaluation process using in some cases artificial neural networks (Rucci et al. 1995, Bocchi et al. 2004).

Auxological evaluation of athletic children. Determining probable chronological age

These are two important areas of auxology. The first has been greatly developed as regards physical morphology (the morphological constitution) and the relationship between growth and such physical capabilities as strength, speed and endurance in reference to various sports (cf. Malina et al. 2004).

The second area is mainly concerned with addressing the needs of magistrates and lawyers in the course of court trials of young or very young individuals accused of crimes and who lack documents giving their date of birth. This is a field, which needs fuller study. In Italy the question often posed by a judge who must formulate a verdict regarding a boy or girl is the following: is this person over or under the age of 14? The probability (%) that a child with a given bone age be less than 14 years old depends on the method of bone age evaluation employed (Table 1), as well as the person applying it.

Table 1. Probability (%) that a child with a given bone age be less than 14 years old according to the method of bone age evaluation employed (prepared by S. Milani).

	Bone age method of bone age evaluation in years			
	GR–PY	TW–XX	TW–RUS	FELS
Girls				
12	99.7	99.3	99.9	99.8
13	91.2	95.7	98.9	79.4
14	54.2	58.7	76.5	76.5
15+	28.6	24.9	46.7	45.2
Boys				
12	99.9	99.9	99.9	99.9
13	92.0	97.9	97.4	96.9
14	51.8	88.6	86.2	75.3
15	20.5	48.0	50.5	37.8
16	1.3	15.9	42.1	3.3
17+	3.9	8.4		

This brief review of key elements and areas of research in auxology shows how this discipline exists inasmuch as it is a field of interest and research shared by various scientific communities, most prominently those of researchers in the fields of medicine, anthropometry, biology and biostatistics. Auxological research generally calls for the participation of scientists belonging to more than one of these communities, among whom geneticists are coming to play an increasingly important role, as emerges clearly from the plenary lecture on *Homeobox genes of development,* with which the 10th International Congress of Auxology was inaugurated (Boncinelli 2004).

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