Body Composition, Somatotype and Growth Type during Childhood

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BODY COMPOSITION, SOMATOTYPE AND GROWTH TYPES

In sports sciences *Body Composition and Somatotype* have a long tradition. The calculation of *Growth Types* has a shorter historical development. Kretschmer (1921, 1951) established a tri-polar classification of constitutional psycho-pathology. This polar division, which can be traced back to Hippocrates, contains only three mutually exclusive, extreme types: the athletic, the pycnic, and the leptosomic (Fig. 1). The classification is made visually according to qualitative characteristics (somatoscopic diagnosis). For sport science, this classification is only limited, mostly historical, significant, if 72% of human physiques (mixed types) cannot be differentiated. A further weakness is the subjective evaluation of the typological characteristics coupled with the postulated polarity of the physique types.

Sheldon (1940) developed a concrete description of physique types, theoretically based upon the development of the embryological germ layers. Similar to Kretschmer, Sheldon distinguished three basic body builds: an endo-, meso-, and ectomorphic type (Fig. 2). Differentiation was accomplished in a subjective manner through use of photographs. The distinctive characteristics were judged according to a 7-point scale. Through this graduated transformation of a subjective impression, it became possible to identify the 72 % that had been labeled as "mixtures" or "variations". This classification, which has been used in sport anthropometry over a considerable period of time, also shows weakness in its assumed polarity of physique types.

The studies of body composition influenced the development of Somatotype (Carter and Heath, 1990) and Growth Type (Herm, 1988). The Heath-Carter somatotype (Fig. 2) is related to, but not synonymous with body composition.

Endomorphy is an estimate of relative fatness. Mesomorphy is an estimate of musculoskeletal robustness per unit of height. Ectomorphy, which is not included in the two-compartment model, adds a third dimension, i.e. the distribution of endomorphy and mesomorphy in space, or, tissue distribution relative to height. The Carter-Heath-Method is the most used somatotypology in sports.

The somatotype during childhood is characterized as part of changing of the body according growth and development.

Other somatotype investigations like Conrad 1963 (Fig. 3, 4 and 5) shows different less relation to body composition if there is more relation to the growth tendencies.

Conrad (1941) attempted to remedy the shortcomings of the Sheldon classifications mentioned above by additional quantitative measures. Because every normal distribution is characterized by two mutually exclusive poles, in this case growth tendencies, Conrad designated these as leptomorphic and pyknomorphic types. He characterized the growth tendency toward the athletic-nonathletic poles by the terms hyper- and hypoplasia. His classification scheme, therefore, has two levels of variation. To locate a position within this scheme, Conrad employed a *metric*- and a *plastic index*. The values of the metric index are derived from body stature, transversal and sagittal diameters of the chest. The plastic index is computed from shoulder width, forearm and hand girth. The two values are then entered in his coordinate System that consists of 81 fields. The center (E5) of this coordinate system, therefore, represents a "metromorphic-metroplastic type". Of particular significance for Sport science is the fact that the system can be used not only for the most diverse types of Sports and Sports events, but also for the evaluation of the physical development of youth (longitudinal and cross-sectional investigations).

The special merits of the system are its practicality, objectivity and its distinctness.

Lundmann (1964) described the classification scheme, based on description of photographs, anthropometric indices as well as physiological data. His model gives an overview of human groups of body form as they are determined to a greater or less degree by race or ethical groups (Fig. 6).

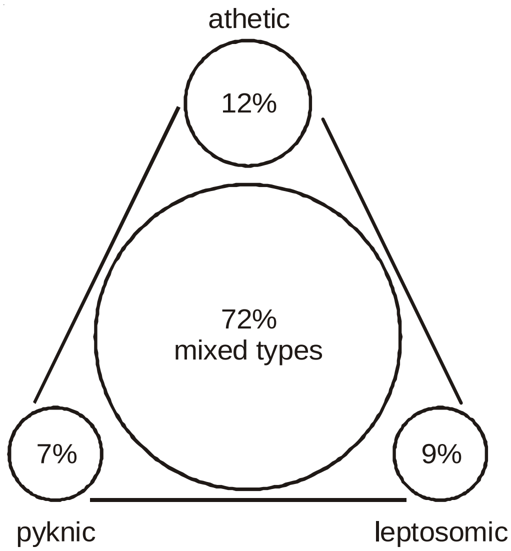

Fig .1.The tri-polar classification of constitutional psychopathology according to Kretschmer (1921).

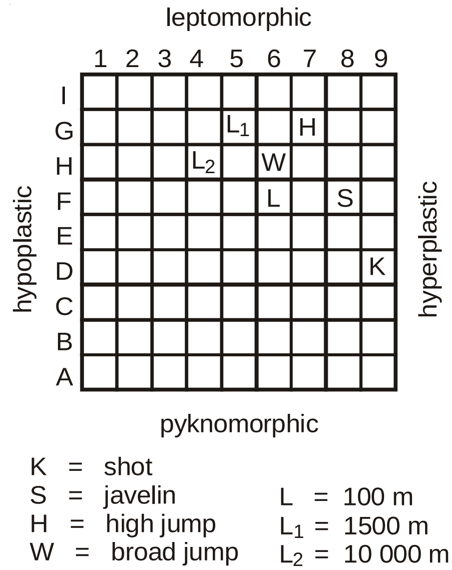

Fig. 3. Somatotype in different sport kinds according to Conrad (1941).

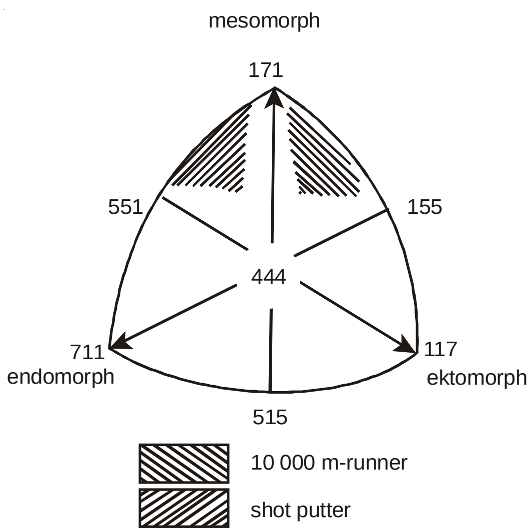

Fig. 2.Sheldon's (1940) description of physique types which further developed from Carter and Heath (1990).

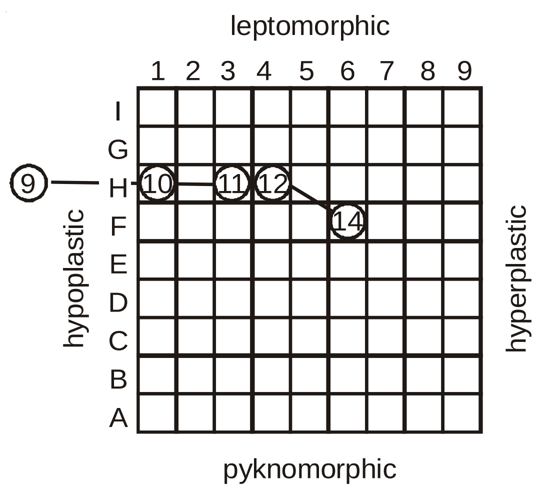

Fig. 4.The indication in soamtotype of age according Conrad (1941)

According the scientifically development in sports *Body Composition and Growth Type* have an influence, to train with the right loading and the talents in different kind of sports.

The results of investigations of growth types and biological age of children have strong contact to changing the proportion and the body composition (Herm, 1988).

The *biological age* is refers to an individual's age as determined by biological maturation and exogenous influences, which may differ from chronological age (Tittel and Herm, 1992).

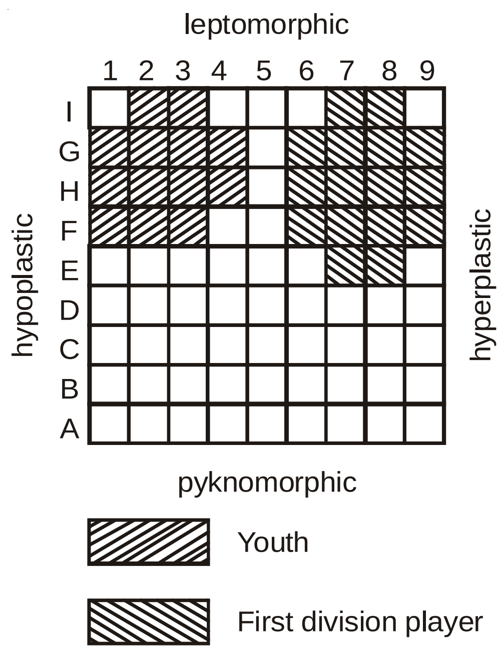

Fig. 5. Different physique type according to Conrad for youth and first division soccer player

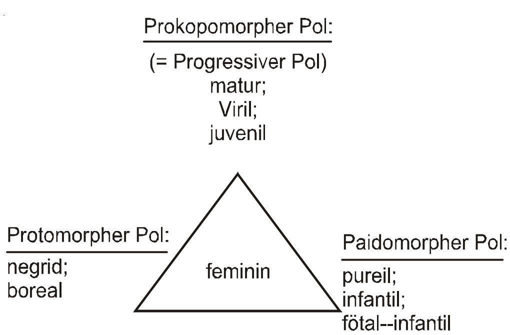

Fig. 6. The classification scheme according Lundmann (1964), based on description of photographs, anthropometric indices as well as physiological data.

Variables for the determination of biological age are: state of the skeletal system, development of primary and secondary sexual characteristics, height body mass, and body surface. Deviations from normal development are characterized either as acceleration or retardation. In the German speaking sports sciences area we find the "body development index" as the method of the choice for estimation of biological age.

Work capacity of children in sports and nutritional requirements are among the variables that depend on biological age. *Note:* Especially at development of puberty, there are great individual differences in biological age among people of the same chronological age. Work capacity must therefore be determined on an individual basis.

The *growth type* is the phenotype of children and is influenced according the *long term growth* and the *short term growth* of body size and body composition. That means, if you like to study the short term growth type, you must investigate the children in a longitudinal study with short distances in investigation, e.g. daily, weekly or maximal monthly steps to describe the growth pattern in youth sport (Herm, 1988).

There are different results to describe the growth types. So you can find the *stable growth type* or the *dynamical growth type*. The stable growth types grow in very stable curve form. The dynamical growth type is changing and turns in very fast growth velocity. So do you can very exact describe the peculiarity of growth.

We have to deals with applications of this approach in two cases. The formula of body composition as a result of biological age and the growth type as a result of differentiation according somatotype and body composition.

There is very good circumstantial evidence that specific growth factors, aside from their role in promoting the proliferation of cells *in vitro* may play a key role in controlling and coordinating differentiation and cell specification in embryonic development.

This evidence comes firstly from analysis of the expression of specific growth factors *in vivo* by *in situ* hybridization or immunohistochemical techniques where it has been found that individual growth factors are not only present in embryonic stages of life but also exhibit distinct and characteristic stage and tissue specific patterns of expression in the course of development.

The second line of evidence comes predominantly from invertebrate systems in which it has been found that amongst those genes, defined by mutational analysis, which control developmental events in early development are some which encode either growth factor-like molecules or growth factor receptors.

Another line of evidence comes from studies on during childhood in which it can be demonstrated that exogenously applied growth factors can mimic the effects of normal tissue interactions in controlling cell fate and differentiation.

Each case highlights different means by which growth factors may control developmental decisions, and strongly suggest that specific growth factors play a fundamental role in generation tissue types and pattern in early development.

MUSCLE MASS, BONE TISSUE AND BODY FAT AS PART OF SOMATOTYPING AND GROWTH TYPES

Muscle Mass

In sports kind we have to analyses the *skeletal musculature* as very important organ of the sportsmen. In Anthropometry is for estimation of muscle mass the method of choice according Natiegka (1921).

The gradual preparation of human efficiency in sports is dependent first of all on the adaptability of skeletal muscular fiber types upon loads. According to our findings intensive strength training caused aerial increases of fast twitch (FT-) fibres by 15.5%, as compared by 10.6 % with slow twitch (ST-) fibres, only. Following endurance – training loads ST-fibres showed aerial increases by 21.3 %, FT-fibres by 16.3% only. It seems remarkable that the oxidative and glycolytical metabolism has been functionally consolidated at the 12th year of age. The investigations gained similar results in the adaptation of skeletal muscle fiber areas and distribution of ST- and FT-fibres during specific sprint and endurance training programs with children and adolescent including de-adaptation after a 6-month-non-training-interval and related activities of succinate-dehydrogenasis and phosphofructokinasis.

While the endurance trained subjects showed an increased SDH-activity by 42%, the sprinters had an increase by 21% in their PKF-activity. After the rest interval these activities returned to significantly lower values.

Contrary to these positive reactions an immobilization of the leg (after an injury) leads in a relative short time to a considerable decrease of muscular fiber airless (in particulare in ST-fibres) by more than 20% and in connection with this to a diminished oxidative enzymatic activity (SDH). We avoid, therefore, in sportstraumatology longer immobilization.

We know that more than 95% of the consumed oxygen disappears in the mitochondries of skeletal muscles during maximal aerobic efforts. Therefore it seems reasonable to register adaptational reactions of them from training stimuli by determining the number of mitochondries as well as the density of their volumes. It could register increased surfaces of mitochondries by 37% and numbers by 18 % after 5 weeks of endurance loads causing and increased oxidative cellular capacity from an enlarged total surface (by 69%) of the Christy mitochondriales, and leading to "supercompensations" during the period of recovery. There is a significant increases of mitochondrial volumes density, particularly in ST-fibres after 6 months endurance training, again supporting the fiber-type-specific reaction upon prospective training stimuli (Tittel, 1996).

Who regulates and controls these biological adaptations? Decisive effects on muscular growth results from the hormones of the peripheric endocrinal organs in particular by thyroxine, by the somatotropical hormone (STH) as well as by testosterone, controlled by hypothalamic nuclei fields. These hormones become highly active during puberty after changing secretional processes (e.g. reduction of suprarenal activity and increasing thyroidalfunction) in form of secretional peaks very sensitively reacting upon training loads. It can be demonstrated in form of the plainly flattened follicular epithet of the glandular thyreoidea immediately after endurance efforts. On the other hand we know that essential improvements of strength capacities can only be achieved after increased testosterone-production and - release and "peripheric sensibilization" towards that hormone. Therefore, strength training should at first be concentrated on the consolidation of motor processes and control of movements during prepubertal stages!

The oxidative capacity of individual muscular fiber types is related to clear training-specific adaptations. We may conclude that the capillary density and capillarisation are also adapting to loads in a similar manner.

The experiments with endurance-trained individuals showed functionally enlarged capillary beds by 45% as compared with the control group caused by an increased metabolism and a higher osmotic pressure and initiates because of a hyper-polarization of the smooth vascular wall muscles of arterioles and pre-capillaries thus an increase of the skeletal muscle's oxygen- consumption up to the 50fold. That capillary density and mean interfibrillar mitochondrial volume density are correlated significantly with endurance loads (e. g. after a 100-km-race). There is a nearly complete depletion of the interfibrillar and lipids, but no evidence of an acute redistricting of mitochondria. The micro-circulation in FTG-fibres is significantly weaker developed at untrained and trainability of trained conditions than in untrained and trained ST-fibres.

These findings to the adaptability of skeletal muscles and their components already in children's and adolescent's age clarify the physical range of performance and the trainability of the point of skeletal musculature pre-suppositions when systematic training programs taking the biological adaptability of musculature into consideration and sufficient periods for active recovery are established; they are more liable within the mass of connective tissues.

Skeleton Mass

The second main organ for anthropometrical measurements of sportsmen is the *bone tissue*. Now some remarks to the adaptability of bone tissue upon regular training loads. The part of skeleton mass is by young as well as adult sportsmen much higher than by non sportsman. The "lamellary" or "breccial" bone possesses manifold adaptation reactions because its intensive metabolism need blood supply; both peculiarities of our total skeleton structure for 5 to 6 times within our life! To the most important adaptations of bone tissue which need as a matter experience about 3 to 4 years regular training belong among others:

- the circumferential growth of corticalis in the short and long tubular bones (demonstrated with a polio myelitis patient, with an untrained person and with a 50-km-walker, all of the same age);
- the enlargement and ventralisation of the supporting areas of the rich capillarized lumbar vertebral bodies;
- the increased osseous formation in the zones of attachment for muscles, tendons and joint capsules caused by high and regular tensile loads;
- slackening in the area of symphysis pubis to be registered among others with younger female gymnasts, and
- changes in the infernal structure of bones in the direction to another increasing sclerosis; example; the femoral-patellar joint.

Body Fat

As the important structure of the body composition for all age in sports is the *body fat* or *adipose tissue*. Lots of investigation we can find about adipose tissue or body fat. Adipose tissue is like muscle mass and skeleton mass also one of aspect to estimate growth type (Herm, 2002). Anthropometric profiles are commonly used as a basis for evaluating the level of body fat in both athletes and other members of the general community. There are a variety ways in which people use these basic anthropometric measurements to quantify over and regional body fat levels (Norton and Olds, 1996). However, over time, many of these methods have been applied without appreciation of the errors and assumptions associated with their use (Herm, 2003). This uncritical use of estimations of body fat is one of the most abused areas of anthropometry. This chapter will address some of the major problems associated with fat estimation using regression equations and suggest ways to minimize the inconsistencies in this application of anthropometry.

Body fat stores changes throughout life in a way which, on a population basis, is quite predictable. Cross and longitudinal sectional data demonstrate that from relative high levels of fatness in the first year after birth, subcutaneous fat Stores slowly decrease to their lowest levels between the ages of 6 and 8 (Tanner, 1962). After this subcutaneous fat rises progressively throughout most of the developing years except for a noticeable dip at about the time of the growth spurt (about 11 to 12 for girls and 14 to 16 for boys). From this point, subcutaneous storage fat increases, reaching a peak during the fifth decade of life for men and the sixth for women, subsequently falling age increases. This latter decline in external fatness is probably a result of selective mortality since fatness is a known risk factor for developing a number of diseases. Since most people are concerned about their level of fatness, estimation of body fat stores is a common procedure performed in settings such as health and fitness centers and gymnasia. Similarly the established relationship between excess fatness and decreased Sports performance has resulted in fat assessment becoming an integral part of the physiological preparation of athletes. In both of these examples, the method used to determine the level of storage fat typically involves taking skin fold measurement. Often these external skin fold measurements are then used to predict total body fat using any one of a number of prediction equations available in the literature. If this method is used there are important assumptions and limitations which must be understood by the measurer in order that a balanced appraisal of the body level can be made. In this way meaningful and appropriate Information can be conveyed to person on whom the measurements have been taken.

The big aim of the investigations of Body Composition, Somato Type and Growth Type during Childhood is to develop the sport art specific kinds of norms for talent selection in children and youth sport.

NORMS FOR TALENT SELECTION IN YOUTH SPORT

To find and develop *norms* for *talent selection* in youth sport is the main task in all sports kinds.

Success and failure in Anthropology of Sports depends on the aim of the investigations. The problem in different kinds of Anthropology is to recognise the individual development of modern *Homo sapiens*. In this position turned and developed the *"Special Norm"* for variant kind of sports. During different investigations of talent selection was found especially in sport differing high degree of adaptation not alone in high performance sport as well as in health or recreational sport - for example in sport for obese children. To develop the right norms in different sport kinds is quite difficult and so it is useful to develop more and more special norms.

To designing special norms is a long and different process and therefore following theoretical and practicable methodical way was constructed (Herm, 1993).

We have to see in Sport anthropology:

1. the general and specific body peculiarities the different sports require, that means the body composition as assumption for sport performance and health;

2. the influence of training and motor activity to the body composition, which means that body composition, is a result of training and motor activity;

3. in this connection it is useful to see the individual differences of body build. In these directions we have to see and to recognise dynamic system of man.

There we use different methods:

1. Cross sectional studies, 2. Longitudinal studies, 3. Mixed cross sectional and longitudinal studies, 4. Pilot studies, 5.Short term investigations, 6. Specific age data, 7. Investigations to determine influenced parameter, 8. Investigations to recognise different aspects of growing children, youth and adult persons like problems of "Biological Age", 9. Investigations about motor and training activities, 10. Different mathematical statistical analysis for developing new models of norms.

The mathematical treatment were: Average, standard deviation and variation, analyses of variation, regression and correlation analyses, cluster analyses, factor analyses, growth curves and estimation of functions etc.

There is the existence of four levels of norms in different sports kinds:

1. Minimum-Norm. 2. Majority-Norm. 3. Ideal-Norm and 4. Special-Norm.

By these examples should be demonstrated the different "pecial norms"for young and adult male and female sports men.

There are three problems:

1. MOTOR ACTIVITIES,
2. MODELS OF SPECIAL NORMS,
3. TALENT IDENTIFICATION AND SELECTION IN KINANTHROPOMETRY

And we have a lot of so different ways to solve the three problems!

One way is to wait at the talents, than they will come to participate in sport.

The other way is the scientifically way - with a special part according the Anthropology in Sports - with estimation of body composition, investigation in growth and development in relation to the physical performance and physiological capability (- my way started 1967 as a student of sports sciences and following of Anthropology of Sports in sports medicine with my first task in Photogrammetry and talent identification and selection according biological age - and now, 40 years later I can say this time to work on these fields was a fascination! It was a fascination with success in theory and practise!).

If you see the theoretical and practical fundamentals of sift and sighting, of judgement and estimation of suitable and for selection in sports than you have also to look at following points:

1. System of talent identification and selection for high sport performance and other areas of all and talented children with different steps during the age from 7 to 20 years.

2. Support the selection for sports schools through reliable sift methods and suitable judgement or manner.

3. To see new development of sport specific norm systems for the training in children and youth sports with different profile of demands for example to the different biological age, growth and development rates of the individuals.

Guide sentences are:

1. Motor activities include performance development.

2. Size of performance development depended on size of the possibilities to develop specific sports performance.

3. Process of development with performance prerequisite and performance development

4. Performance result in relation to performance prerequisite and in relation to the calendar, to the biological and to the training age.

There are different possibilities and methods for developing talent selection.

For solving the problems where used different kind of measurement technique and methods to investigate the dynamic of development of young sportsmen.

Anthropometry (Size, weight, body compartment, somatic type, biological age, growth and development, growth types, etc.),

Tests for motor activity and sports performance etc., investigations, specific age data, investigations to determine influenced parameter,

Analyses methods like cross and longitudinal studies, pilot studies, short term growth and development analyses, simple and comfortable mathematical and statistical analyses and *Sports scientifically practical and theoretical work* (Malina and Bouchard, 1991).

For the *MOTOR ACTIVITIES* there is an important task in norms and talent selection. Motor activity expresses a certain perspective for the study of human movement which is based upon the concepts of action theory. The action-oriented perspective is characterized by the attempt to do justice to the complexity of the human system and to man's relative freedom in all aspects of his behaviour e.g.

- talent scouting,
- objective and realistic performance development possibilities of the talent,
- prognostic possibilities of motor activities of the talent,
- size of growth and development of the sport performance,
- relation between result of sport-performance and performance-somatic-prerequisites in connection with the biological age, calendarical age and the age of training,
- the process of estimation of the physical aptitude, of the general aptitude and the talent determination
- the kind of talent promotion,
- kind, form, frequency intensity content and type of sport training as well as training load,
- training duration etc.

Motor development, therefore, would deal with the "Neuro cybernetic characteristics, including subjective factors and conscious awareness", whereas movement is characterised as the change of place of the human body mass in time and space which is manifest on the periphery as an objective process. In this way, there is a clear distinction between the totality of all regulating processes and functions on the one had, and the diverse outcomes of the process, human movement, on the other hand.

The foundation of motor performance, therefore, can be understood as the totality of all regulative and functional processes which form the basis for a purposeful, voluntary motor activity. Motor performances are dependent on inherited and learned automatism, stereotypes, abilities, and skills.

The training program includes all part of the motoric activities like the example of analyses for talent selection in different kind of sports like figure 7 and table 1.

You have to determine following norm for talent selection:

1. Norms for the first selection,

2. Norms for control the development,

3. Special norms for sports training of top level athletes

For every sports kinds is useful to develop *MODELS OF SPECIAL NORMS.* The relations between anthropometrical measurements, like muscle mass, height, mass, bone mass, active body mass, thigh circumference etc. to the motoric development and to the performance in special

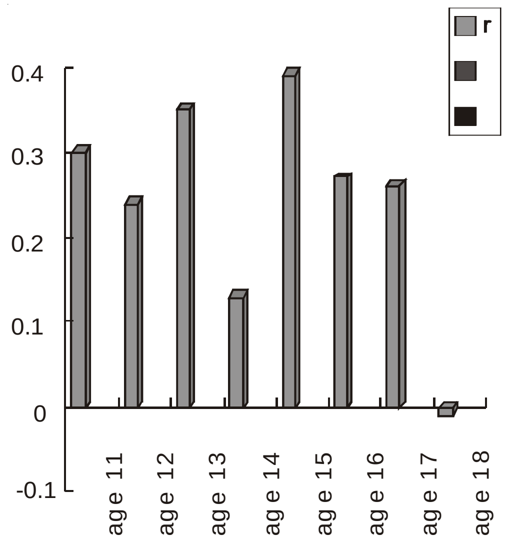

Fig. 7. Correlation between biological age and long jump performance

discipline have in all age groups different influence.

In sport it is not the concrete actions of a game, but rather norms in the form of the rules of the game which constitute a type of sports. A relay race, high jump, a game of European handball etc. are, not only actions of simple individuals, but first of all number of norms. We don't need in the special case of information the scientifically investigation as a "ermeneutic" work, that means, they are restricted, at what you like to answer, if you asked for this. The norm in Anthropology of Sports is pattern, model, sample, scale, standard, direction, directives, level, guiding principle etc. Norm is not a constant of material but it is outlined according a lively dynamic and there are stamped possibilities of changing and they are to recognise at the given characteristics for example as adipose tissue according skin fold measurements.

We have narrow connexion between movement and Sport anthropology and we described that way the four levels of norms: 1. Minimum-Norm, 2. Majority-Norm, 3. Ideal-Norm and 4. Special-Norm.

The Special-Norm is the condition for a specifically (body/physical) activity and performance.If somebody like to reach a special norm you need a multiple analyse with parameters like calendarical-, biological- and training age, like motoric and somatic development (see Fig. 8).Every sports kind has very importance factors of performance like speed during running and force during jump (long jump). And you have to develop the right contents of training for these tasks. Also for every kind of sports it is important to fix the time points of talents selection, to see

Table 1: Indication marks and specific of age during the process of training as an example in long jump between the age 11 and 20 years (Herm, 1998)

age	*step of training and selection*	*institution of promotion and main points of training*
11-12	fundamental training	responsible: free training in sports clubs and in the school
12	first standardised and organised talent selection	contents: track and field norms
13-15	building up training step 1	responsible: fundamentals in the sports organisationcontents: various training in kinds of sports, e.g. running, jumping, throwing
15	second standardised and organised talent selection	responsible: federation of sports norms responsible: federation of sports contents: long jump specific and various training
16-17	building up training step 2	responsible: federation of sports, norms
17	third standardised and organised talent selection (central competition of the federation)	responsible: guest house for sports, central training campscontents: powerful individual and specific long jump training
18-20	additional training	responsible: guest house of sports and central training campsview of talent selection: recognition of talents in long jump
19	fourth standardised and organised talent selection as a central national youth competition)	responsible: national federation of sports, central training camps
20	high performance training	contents: individual and specific long jump training

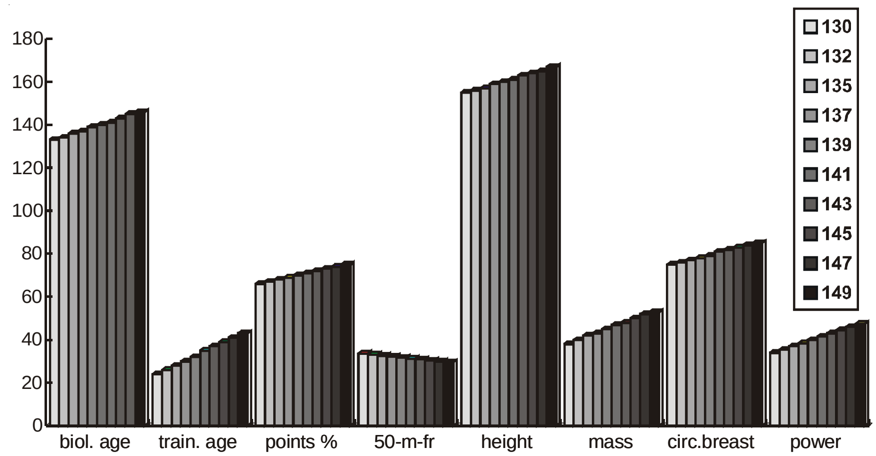

Fig. 8. Relation between result of performance, performance assumption and time parameters as a result of physical aptitude in swimming (age in month).

which standardized talent identification tool is most appropriate and equate the many aspects of training.

You can e.g. according the model of none linear regression estimate the norm if you have in the age groups high correlations. And according the polynomial of third degree with the main land marks and the main motoric points you can estimate the adapted function with a good practical result.

The right *TALENT IDENTIFICATION AND SELECTION IN KINANTHROPOMETRY* will

$$X = \frac{\textit{Test performance}}{\textit{Norm}} * 100\%$$

contribute to train the top level athletes and performance (Fig. 9).

According the adapted function:

Land marc $= a + bx + cx^2 + dx^3$

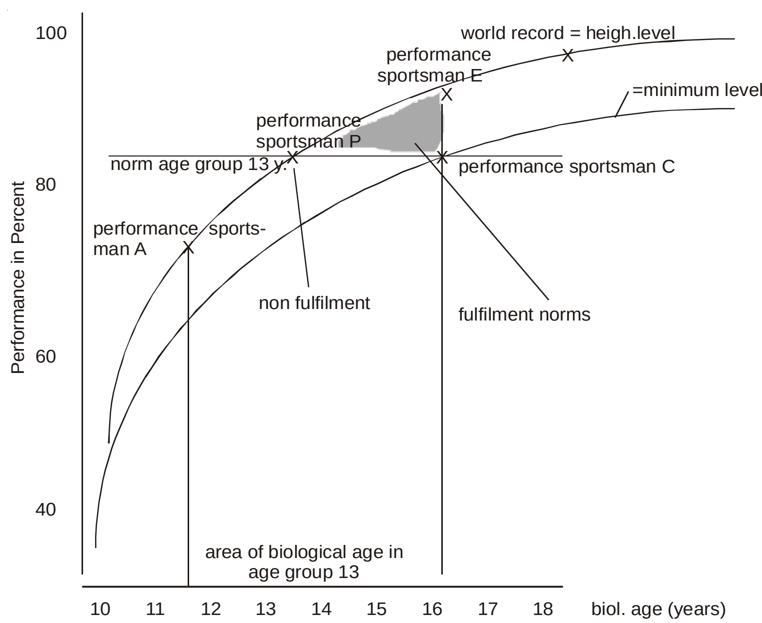

Fig. 9. Example for talent selection as a problem (Herm, 1998)

You can estimate the norms in different age groups and sports kinds.

After determination of the special norms you can calculate the individual position of the young sports man according the formula:

According the investigations in different kind of sports is it possible with special norms to realise, that 16% of the investigated young sportsmen reach this norms and the individual equal the formula above estimation you can see at figure 9.

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ABSTRACT The collected experiences to estimate Somatotype and the used anthropometrically methods to estimate body composition (muscle mass, Skeleton mass and fat mass) as well as the developing and use of biological age and growth types in different kind of sports can be use in all other kinds of sports in different countries on the world. With the methodical way of the investigations described above *Body Composition, Somatotype and Growth Type* during childhood, it is possible for young sportsmen in different kind of sports, using the models for the first time meant that the result were applicable for a longer period, is valid for the whole year and for the age groups from 11 to 20 years. Talent identification and selection is connected with "*Models of special norms*" in Anthropology of Sports. The objects are- 1. To secure data on body measurements which reliable describe the characteristics of group, race or stock being studied, and 2. Publish the data in a form which may be readily and safely used for anthropological comparisons and deductions.

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