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The morphological age and weighted evaluation of the neuromuscular qualities of the young player

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ABSTRACT

This study aims to answer some questions concerning the aspects relating to the anthropometric and neuromuscular evaluation of the young football player.
Objectives: The points on which we try to clarify are: 1- seek an indirect criterion for determining the biological age that complements and integrates the one most, to date, adopted proposed in 2002 by Mirwald et al. (22), based on the determination of PHV and APHV, since this would seem quite reliable with subjects with normal maturation but not so much when they are late or early; 2- determine for each chronological age and for each of the tests used in the study the Gold Standard Range Improvement (GSRI) expected to know

if, basically, a detected improvement can be considered Regular Improvement, i.e. attributable to the normal physical maturation process rather than Irregular Improvement, that is attributable to other factors such as training; 3-identify the ABAEI (Age Best Average Expected Improvement) of jumping ability (CMJF), 20m sprint ability and agility ability to verify the actual presence of one or more favourable moments, between 7 and 17 years , where it is easier to achieve significant improvement; 4- provide a sufficiently reliable method to interpret the results of the neuromuscular tests considered in the study without these being influenced by the degree of maturation; 5- understand if the selection criteria adopted, in a professional context such as the one we have observed, tend to favour individuals with early maturation.

Materials and methods: A sample of 827 footballers aged 7-17 and belonging to the youth sector of a professional Swiss super league club, was subjected to a longitudinal analysis, relating to some anthropometric measures (weight, height, chronological age, BMI) together with the results of three field tests (CMJF, sprint on 20m and agility). For the indirect determination of the biological age, a model was developed with which to calculate the morphological age on young players who train regularly, therefore on average thin, normal weight, starting from the measurement (twice a year) of weight, height, chronological age and BMI.

Results: From the analysis of the data, it emerged that the observed sample was found to be on average early since it reached PHV at least one year earlier than what is reported in the literature by Parizkova in 1976 and Malina et al. in 1999 (19,13). In the 7–17-year period, the average performance improvement of each of the tests administered was significant and constant (2.8% -12.8% for CMJF; 2.2% -6.4% agility; 2.02% -6.48% sprint 20m). However, CMJF and sprint 20m provided the same ABAEI (8-9 years) while for agility the ABAEI seems to coincide with the 9–10-year period. The GSRI was calculated for each age and for each of the tests considered in order to provide field technicians with a reference range that allows them to check whether the improvement obtained by their children can be classified as Regular or Irregular Improvement.

Conclusion: The analysis of the results allows us to make some interesting considerations: first, there is a tendency to favour subjects with early maturation. Starting from simple anthropometric measures, it is possible to calculate a further indirect indicator of maturation, the here proposed morphological age. Since this together with the determination of the PHV can help us to approach the biological maturation of young players and to weight the test results in relation to the degree of maturation. Finally, the ability to jump acceleration on 20m and agility naturally improve during the whole period 7-17 even if with differences depending on the age. While for the CMJF and for the agility there are no evident variations in the percentage of improvement, for the acceleration capacity the period between 8-11 years and that between 14-16 years seem to be more sensitive to improvement.

Keywords: biological maturity, young player, morphological age, quality neuromuscular, sensitive phases, performance improvement, weighting of results, data anthropometric, agility, cmjf, sprint 20m

INTRODUCTION

Programs aimed at selecting talent in sport, for example in football, tend to focus on the tactical and technical aspects. However, by omitting aspects such as anthropometric, physiological, psychological and sociological data, there is a risk that players will escape the selection process, especially those with a late maturation as observed in 2018 by Dodd and Newans (8). The purpose of this article is to focus on some evaluation methods, necessary to trace, through a few simple measurements, the auxological profile of the young “elite” sportsman, together with the analysis of the results of the tests that made it possible to obtain the trend of ability (Counter Movement Jump Free, CMJF), acceleration (sprint, 20m) and agility from 7-17 years of age, a particularly important period, since it accompanies the young person in his / her psychophysical development path.

In addition, a model of prediction and normalization of the results of the acceleration test (sprint, 20m), jump test (CMJF) and agility test will be introduced, weighting them according to the degree of Morphological Age (MA). First it is appropriate to answer this question: why the selection of the young “elite” sportsman cannot ignore the understanding of his biological age? There are at least three good reasons. The first is that, still frequently, the most mature young people are selected for the regional and national teams when instead the selections should take into consideration the state of biological maturity. The second reason, concerns the Relative Age Effect (RAE) which exists when the relative age quarter distribution of selected sports groups shows a biased distribution with an over-representation of athletes born in the first months after the specific cut-off date for the competition categories, represents another problem in the talent development, as observed by Muller et al. in 2015 (10). The third reason concerns the Effect of Relative Age Assessment (ERAA), i.e., when the results of athletic field tests (for example sprint or counter movement jump tests) are not normalized by Biological Age (BA, that is, an indicator that reflects the degree of maturation of the young athlete) but by Chronological Age (CA). In the presence of an effect of relative age assessment, it is likely to lead to evaluation errors that can cause an overestimation or underestimation of the athletic potential of the young sportsman. In this study we tried to create a weighted evaluation model to answer the following question: within a group of young “elite” sports students, how is it possible to normalize the results of the 20m sprint tests carried out by three young people with same CA (14 years) and same performance (3 ’21’ ‘) but with different BA in which one is normal, the second early and the third late? Everyone agrees on the need to determine the BA through indirect measurements done quickly and safely, to avoid too high costs and, above all, exposure of the same to dangerous radioactive emissions (rx) as required for the determination of the SA (skeletal age). To date, the traditionally most used and adopted methods to go back to the BA are the evaluation of the skeletal age the best-known method is the Greulich-Pyle 1959 based on the original work of Todd (1937) which involves an x-ray of the bones of the hand. Another way of measuring to trace the degree of biological maturation is the observation of secondary sexual characteristics (9). Another indicator is dentition, although teeth have very rarely been used as an indicator of maturity in studies of young athletes. In sports increasingly adopted as an indicator of maturation, for example in bio-banding applications as reported in 2017 by Sean et al. (23), the calculation of the percentage of expected height close to height that the young person will have as an adult. Yet another type of widespread evaluation is the determination of Peak Height Velocity (PHV, the time period in which a youth experiences the greatest increase in height) and the Age at Peak Height Velocity (APHV) in 2002 by Mirwald et al. (22), starting from some anthropometric measures: height, weight, seated height. This method allows you to know, with relative precision, what is the temporal distance in the young sportsman from the growth peak or from the age coinciding with the moment of maximum growth speed in height.

However, to date, there are still too few transversal studies carried out in the school or sports context in the youth sectors, especially those where it has been possible to monitor the path of adaptation of physical qualities to the training proposals during the passage in the different categories over a ten-year period, which includes a good part of the entire growth period (7-17 years). Only starting from this data collection is it possible to think of developing a long-term development model, both auxological and physical qualities, sufficiently responsive to the growth physiology of "elite" young sportsmen. The graphs 1 highlight a well-known reality, to which our data are no exception.

The chronological age was determined, through a spreadsheet, as the difference in days between the date of the test and that of birth dividing the result by 365.
The first line: significant correlation between age and anthropometric data, while in the second, the first two graphs show a significant improvement in performance with increasing chronological age, while the last graph shows that most of the athletes selected to be part of the higher categories were born in the first two quarters of the year. Let's consider the graphs concerning the performances. The coach of a twelve-year-old team, for example, is led to consider the athletes who are positioned in the lower part of the highlighted oval as better performing. Again, we consider the data in tab1 belonging to four different athletes with the corresponding characteristics (real data). The id1 and id2 athletes have practically the same age and the similar performance on the 20m test, but the anthropometric data are profoundly different. Conversely, id3 and id4 athletes have almost the same levels on anthropometric parameters and the same performance but have two years of difference. Hence, the need to introduce an indicator that allows weighting of performance, purifying the data from the different degree of maturation that children with the same CA could physiologically have (and often have). Starting from the detection of weight, height and therefore BMI, which can be obtained with negligible error compared to the results of interest, it is possible to estimate what we will call "morphological age (MA)".

Since there have already been studies, carried out on young subjects such as that by Parizkova in 1976 and Malina et al. in 1999 (19,13). which show that at + 3 years and – 3 years from the peak of growth (PHV) in the first study and in the period 13-15 years in the second study there is a significant increase in body weight (7kg /year) attributable to a considerable increase in % of FFM rather than % of FM, which would even suffer a loss of 0.5% / year in the same period as reported by Malina, 1988 (13). It is presumed that the weight and stature increase, in young “elite” sportsmen, is even more highly correlated (r = 0.60) with a change in body composition and with the increase in the% of FFM as reported in Parizkova, 1976 (19), rather than with the FM % which is obviously lower than the groups considered by the two authors. Therefore, knowing how the Morphological Age (MA) varies in the different age groups could be very useful to verify if there is a possible difference in morphological growth between the MA detected individually and the average values of young “elite” players with the same chronological age (CA). By comparing MA with CA, it is possible to know if the maturation is close to being normal, late or early.

Having many observations (about 2400) on the 20m sprint, CMJF jump and agility tests, it was possible to know the longitudinal trend of neuromuscular qualities, obtaining a specific range (mean value ± dev. St) expected for each band of age. This range can be considered as the GSRE (Gold Standard Range Expective). This reference is essential to understand how any improvement obtained by the young person should be interpreted when the test is repeated. Comparing the improvement with the GSRE, we could know if the improvement obtained corresponds to an RI (Regular Improvement) if the improvement falls within the GSRE or corresponds to EI (Ecological Improvement) if the improvement is greater than the GSRE. In this case it would be an ideal improvement and at worst, if the improvement were lower than the GSRE, we would have a BI (Bad Improvement).

METHODS

Participants

The measurements (overall about 2398) were carried out on a sample of 828 young athletes belonging to professional football club in Switzerland. On average, two measurements per year were carry out at six months. To date, the results of the study according to the SITAR model that dealt with individual growth, would seem to show that making more than two height measurements per year, is to be considered irrelevant to have a precise measurement (Tim James Cole – Optimal design for longitudinal studies to estimate pubertal height growth in individuals Annals of human biology 2018, vol. 45, NO. 4, 314-320).

Anthropometric measurements

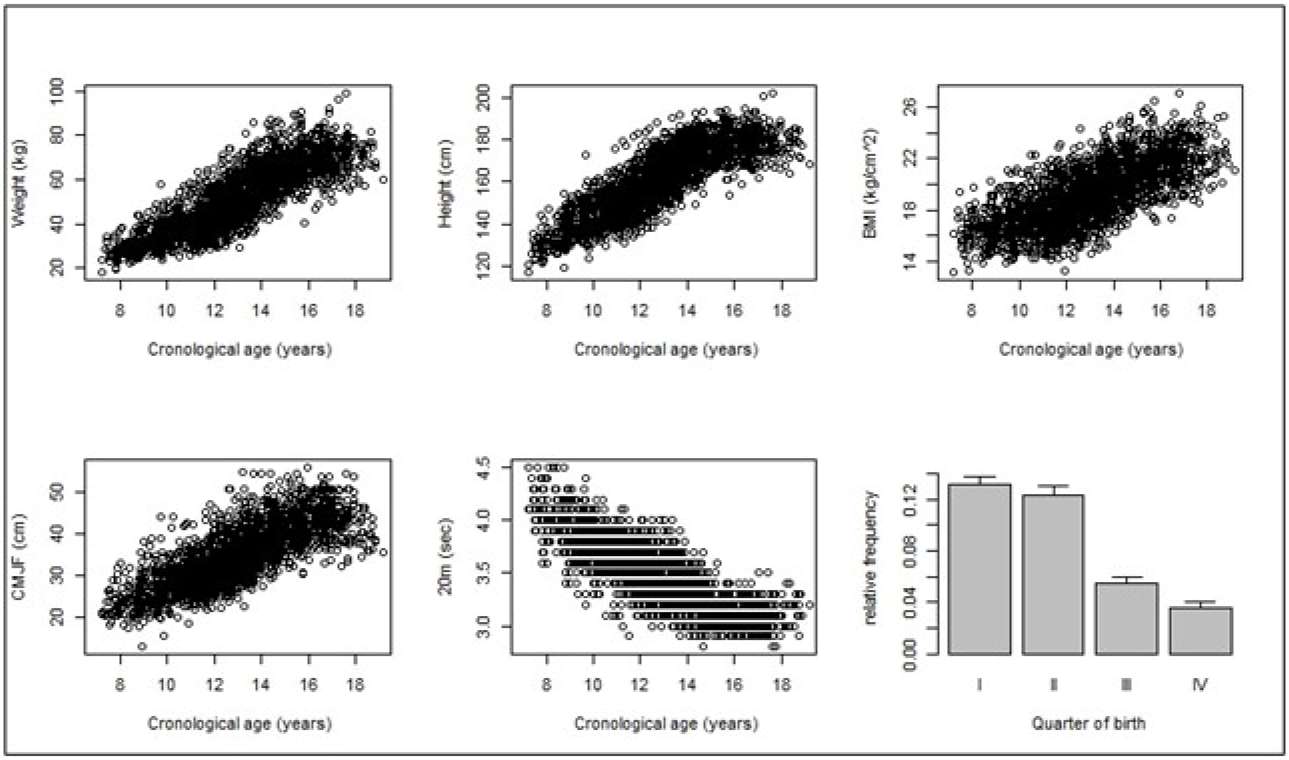

Figure-1 Scatter Diagram of the morphological parameters in relation to the chronological age. Bar diagrams with quarter of birth distribution.

Table 1. Some examples of performances in relation to chronological age and morphological characteristics

athlete	chronological age	weight (kg)	height (kg)	time (sec)
id1	11.0	28.3	139.0	3.7
id2	11.0	37.2	147.0	3.7
id3	11.1	28.4	133.0	3.7
id4	8.9	28.4	134.4	3.7

For the study, the developmental period considered was, between 7 and 17 years, during which data relating to anthropometric measurements, chronological age, weight, height, seated height, length of the lower limb were collected. The measurements were taken with the approximation of 1mm as used by Simmons in 2000 (24) for the height and by using a digital scale (to the nearest 0.01 kg) for weight detection. the descriptive statistics relating to anthropometric parameters and performance are collected in table 4.

Below we report the progress of the anthropometric growth process of our sample. We measured the weight gain and height gain for each year by proceeding as specified below. We restricted the data to the athletes for whom we recorded at least two successive measurements, more than 6 months apart and less than 18, and by weighting the result at 12 months (similarly to what will be done in the performances, and which is reported in table 14), we obtain the data reported in the tables 2 and 3 and represented in the figures 2 and 3.

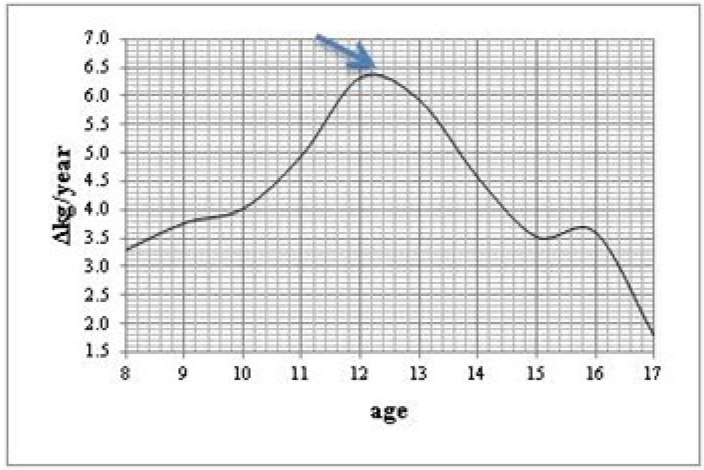

Figure 2 Weight gain in kilograms

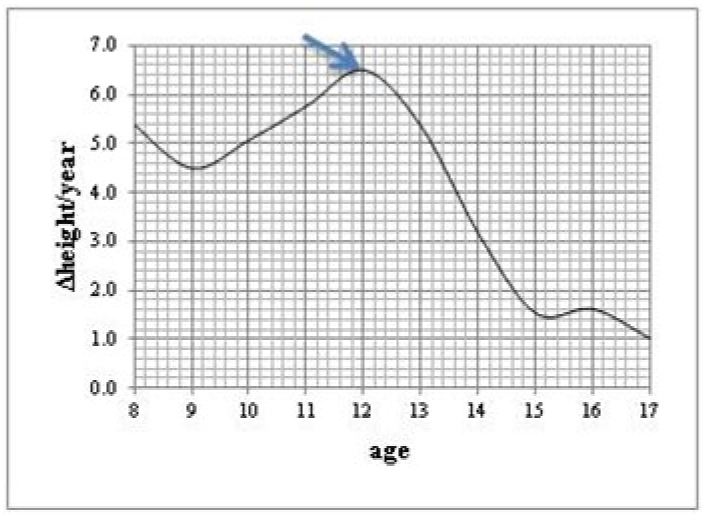

Figure 3 Height gain in cm in relation to age

Tables 2-3. Mean and standard deviation of weight and height of athletes by age group.

age	*weight*	*s.d.*	*n.*
7-8	*3.8*	*1.3*	*18*
8-9	*3.3*	*1.4*	*44*
9-10	*3.8*	*2.7*	*54*
10-11	*4.0*	*2.4*	*91*
11-12	*5.0*	*2.9*	*116*
12-13	*6.3*	*2.8*	*134*
13-14	*5.9*	*2.9*	*109*
14-15	*4.6*	*2.6*	*88*
15-16	*3.5*	*2.2*	*72*
16-17	*3.6*	*1.8*	*30*

age	*height*	*s.d.*	*n.*
7-8	*7.2*	*1.2*	*19*
8-9	*5.4*	*1.6*	*49*
9-10	*4.5*	*2.5*	*66*
10-11	*5.1*	*2.1*	*95*
11-12	*5.8*	*2.4*	*118*
12-13	*6.5*	*2.4*	*138*
13-14	*5.4*	*3.1*	*111*
14-15	*3.2*	*2.5*	*82*
15-16	*1.5*	*1.0*	*60*
16-17	*1.6*	*1.8*	*18*

As it is possible to observe the peak of growth (the Peak Height Velocity, PHV, the time period in which a youth experiences the greatest increase in height), and Pulse Wave Velocity, PWV occur in the 12-13 years range, therefore on average one year earlier than expected for subjects with normal maturation as reported by Parizkova in 1976 and Malina et al. in 1999 (19, 13) These observations confirm what Muller et al. in 2015 (10) already found with relative age, namely, that, to date, the selection of elite athletes favours precocious subjects.

Table 4. Mean, median and standard deviation of the anthropometric characteristics and of the observed performances.

Age		7	8	9	10	11	12	13	14	15	16	17
n. obs.		37	124	174	225	340	347	372	286	230	187	98
Height	mean	128.0	134.3	141.5	146.3	152.1	159.8	167.6	173.7	176.8	178.3	178.9
	median	127.6	133.0	140.8	146.0	151.8	159.6	168.0	174.1	176.9	178.2	179.0
	sd.dev	6.3	6.2	7.3	8.0	8.9	9.6	8.9	7.4	6.6	6.4	6.7
Weight	mean	26.6	30.0	34.3	37.4	41.7	47.6	54.9	61.6	66.3	69.4	70.7
	median	26.1	29.6	33.8	36.4	40.5	46.6	54.9	61.0	65.5	69.0	70.5
	sd.dev	4.0	4.4	5.6	6.1	7.3	8.4	8.9	8.8	8.0	7.4	8.0
BMI	mean	16.11	16.51	17.02	17.34	17.91	18.51	19.44	20.34	21.16	21.79	22.02
	median	16.02	16.33	17.00	17.08	17.76	18.45	19.38	20.18	21.12	21.93	22.01
	dev.st	1.37	1.43	1.64	1.61	1.76	1.68	1.74	1.80	1.72	1.55	1.55
Cmjf	mean	23.22	24.85	26.80	28.83	30.40	32.90	36.39	39.81	42.10	43.44	43.93
	median	22.10	24.55	26.55	28.50	30.00	32.40	35.60	39.80	41.50	43.30	43.70
	sd.dev	3.14	3.79	4.12	4.09	4.33	4.90	5.39	4.78	4.71	4.27	4.65
20 m	mean	4.12	3.98	3.82	3.69	3.60	3.50	3.37	3.24	3.12	3.10	3.07
	median	4.13	3.98	3.81	3.69	3.60	3.50	3.35	3.22	3.11	3.08	3.06
	sd.dev	0.23	0.27	0.22	0.19	0.19	0.19	0.19	0.17	0.12	0.15	0.14
Agility	mean	8.88	8.46	8.15	7.86	7.63	7.42	7.19	7.02	6.86	6.78	6.78
	median	8.81	8.48	8.12	7.88	7.63	7.40	7.18	6.99	6.83	6.79	6.76
	sd.dev	0.59	0.47	0.41	0.33	0.32	0.33	0.30	0.27	0.25	0.24	0.25
PHV	mean	-5.27	-4.76	-4.13	-3.71	-3.09	-2.40	-1.52	-0.55	0.70	1.83	3.91
	median	-5.22	-4.79	-4.13	-3.72	-3.12	-2.51	-1.59	-0.60	0.53	1.46	3.91
	sd.dev	0.32	0.31	0.33	0.30	0.45	0.63	0.63	0.67	0.89	1.03	1.79

Jump test

The jump test used was the CMJF (Counter Movement Jump Free) or the maximum jump performed with a free counter movement, i.e., without the constraint of the arms held at the hips (CMJF, C. Bosco et al 1982). The test was repeated three times and the best one recorded. The height of the jump was detected by means of a system, called “optojump”, equipped with optical detection consisting of a transmitter and a receiver bar.

Acceleration test

The acceleration test was carried out over 20m, using the start on the three supports (the supporting hand is that of the side opposite the first leg), after having carried out a standardized warm-up protocol lasting a total of 20 minutes, which included: 5minutes of continuous running, 5 minutes of general joint mobility exercises, 5 minutes of dynamic stretching exercises; 5 minutes pace + sprint 5 / 10m. The measurement of time was detected to the hundredth of a second using photocells. For each test three maximal tests were performed, with a recovery of at least 2 minutes, of which only the best test was recorded.

Agility test

The agility test includes the start on three supports (fig. 4) and a total run of 23 meters in which the following activities are carried out: start with three supports, forward run, 3 changes of direction (the first on the right after 6.30 m; the second on the left after 5m; the third after another 5m) and 6.30m run backwards (fig. 5). The measurement of time was detected to the hundredth of a second using photocells. For each test three maximal tests were carried out, with a recovery of at least 2 min, of which only the best test was recorded.

Figure 4 Correct starting position with three supports

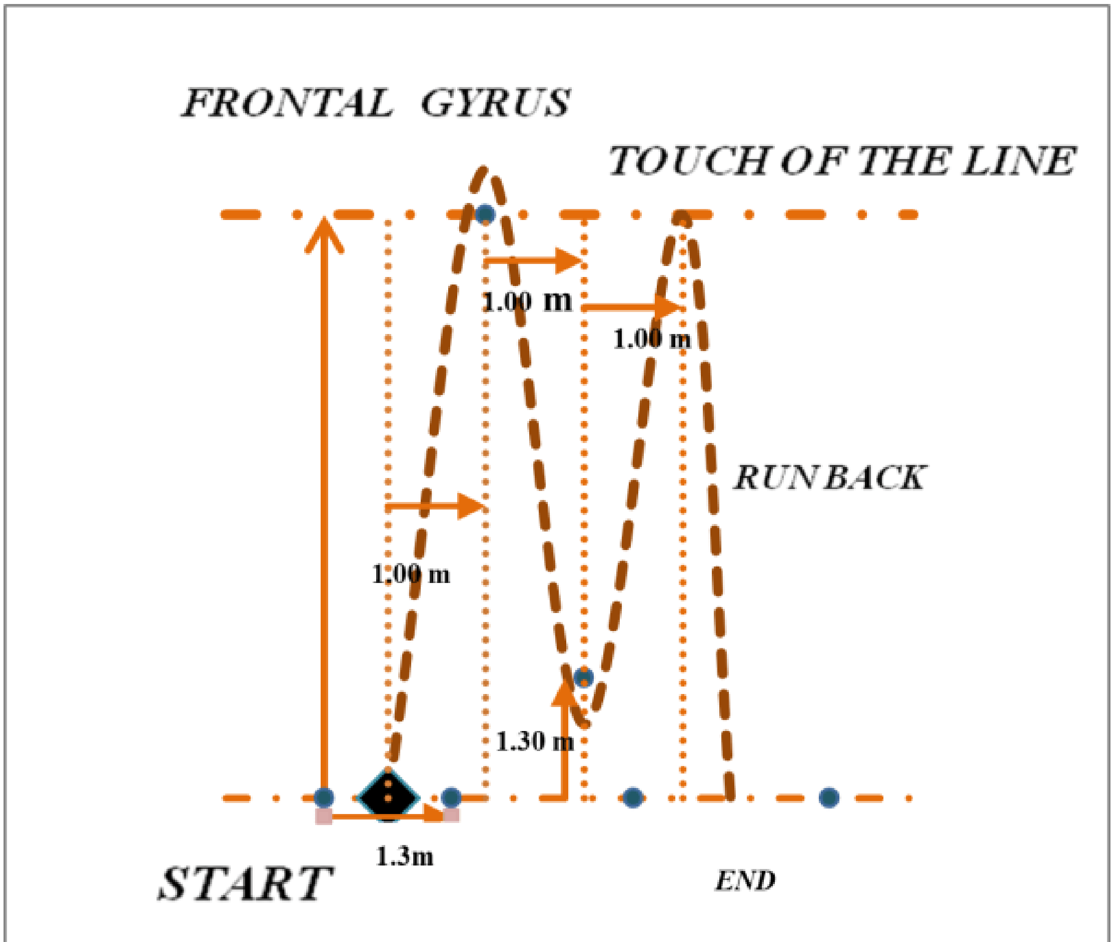

Figure 5 Agility Test Execution Protocol

Statistical Analysis

Factor analysis was used to derive the morphological age. The validity, via the Kaiser-Meyer-Olkin factor adequacy (MSA) and the Bartlett test are reported. The significance of the mean value of the single samples, that of independent samples and that of the correlation coefficients of Bravais Pearson were evaluated with the appropriate t-tests. Multiple linear regression was performed and R-Squared reported. (Table 5) The usual tests on the residues performed. The alpha significance level was set <0.01 The graphs and calculations were made with Excel and with software R.

Table 5. Bravais Pearson correlation coefficient between observed variables.

	CA	Weight	Height	BMI	PHV	CMJF	20 m
Chronological age	1						
Weight	0.845	1					
Height	0.886	0.947	1				
BMI	0.604	0.859	0.670	1			
PHV	0.931	0.866	0.862	0.652	1		
CMJF	0.773	0.676	0.730	0.431	0.710	1	
Sprint (20 m)	-0.826	-0.710	-0.768	-0.475	-0.739	-0.852	1

Note. All the value significant different from zero (t-test $p<0.001$)

The CPMA model: the morphological age.

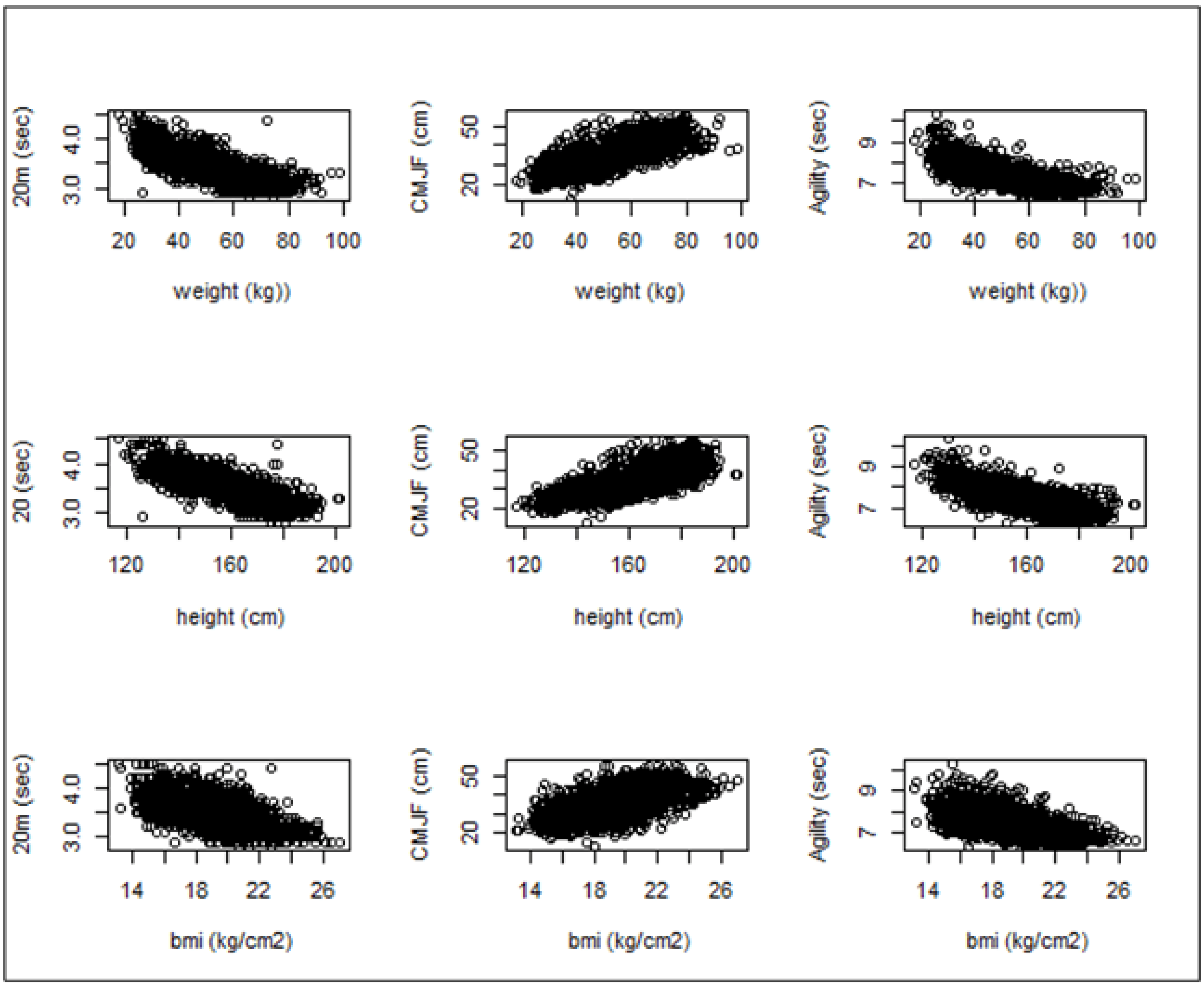

Figure 6 Scatter diagrams of the performances related to the morphological parameters

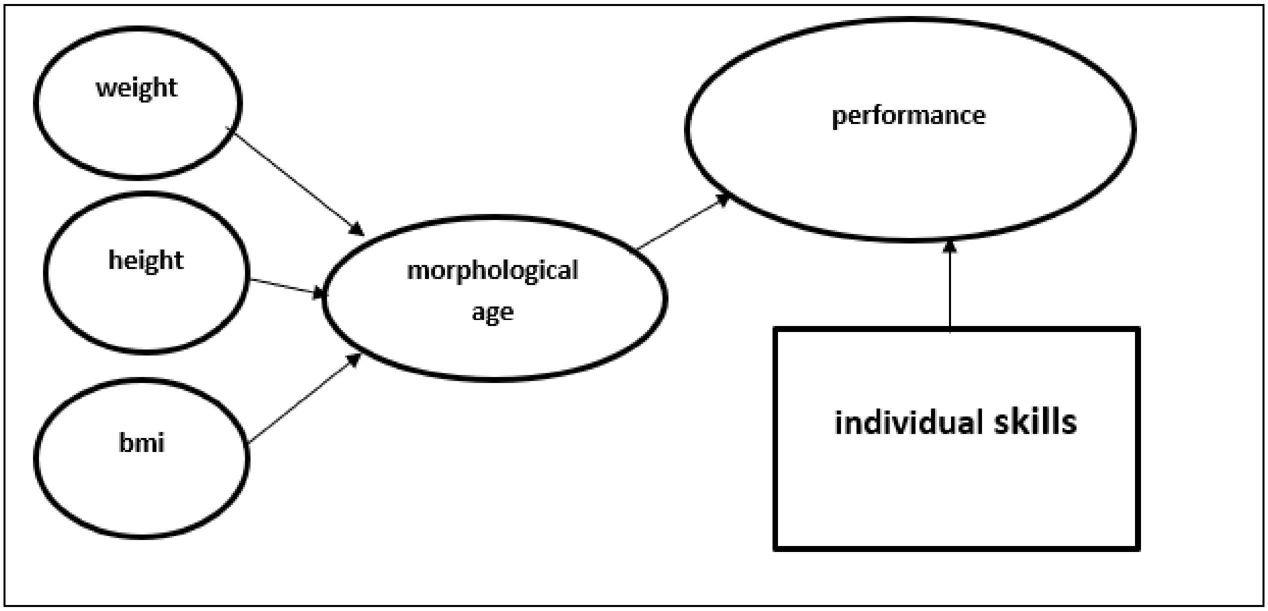

Figure 7 CPMA Model

The fig. 6 shows how the performances are correlated with the anthropometric indicators of the athletes.

As anticipated, the purpose of this work is also to suggest a weighting of the anthropometric parameters, which can be used in the performance evaluation in order not to penalize a late athlete or, equivalently, not to reward an early one. To be usable by as many physical trainers as possible, this tool must be economical, easy to implement and at the same time efficient.

To determine the expected average age given the anthropometric characteristics, it would be sufficient to regress the age on these parameters, but, as we have seen, these parameters are extremely correlated with each other and as is known (30), the estimates of beta coefficients are unstable in this case with high standard errors. To overcome this problem, we first proceed with a factor analysis by taking the first main components (16). These components are linear combinations of the variables that maximize their variance and are independent of each other. The construction is as indicated below.

Starting from the raw data of weight (w_i), height (h_i), and bmi (bmi_i) of the i-th athlete, the standardized scores were obtained,

$$z_i^W = \frac{w_i - \mu_W}{\sigma_W} \quad , \quad z_i^H = \frac{h_i - \mu_H}{\sigma_H} \quad , \quad z_i^{BMI} = \frac{bmi_i - \mu_{BMI}}{\sigma_{BMI}}$$

where μ and σ are the mean and standard deviation calculated on the entire available database. That the score of the ith athlete in the jth main component is thus given by:

$$p_i^j = a_{j1} \cdot \frac{w_i - \mu_W}{\sigma_W} + a_{j2} \cdot \frac{h_i - \mu_H}{\sigma_H} + a_{j3} \cdot \frac{bmi_i - \mu_{BMI}}{\sigma_{BMI}} \qquad i = 1, \dots, n; \qquad j = 1,2 \tag{1}$$

The first two main components summarize 99.8% of the information contained in the anthropometric variables used. The Measures of sampling adequacy, MSA, is equal to 0.876, while the determinant of the correlation matrix is equal to 0.006, thus respecting the requirements usually required to proceed with a factor analysis (12).

All that remains is to regress the chronological age with the factorial scores obtained to quantify the expected average age (MA) resulting from the anthropometric characteristics of the individual. For this purpose, a multiple linear regression is performed.

$$chronological\ age_i = \alpha' + \beta'_1 \cdot p_{1,i} + \beta'_2 \cdot p_{2,i} + \varepsilon_i \qquad 1, \dots, n \tag{2}$$

Where the residual an indicator of the over / under maturation of the athlete compared to the average of the athletes of his age.

Finally, we have:

$$morphological\ age_i = \widehat{chronological}\ age_i = \alpha' + \beta'_1 \cdot p_{1,i} + \beta'_2 \cdot \mathrm{p}_{2,\mathrm{i}} \tag{3}$$

Once the beta coefficients have been determined, a combination of the shape is then obtained:

$$morphological\ age_i = \alpha + \beta_W \cdot w_i + \beta_H \cdot h_i + \beta_{BMI} \cdot bmi_i \tag{4}$$

where:

$$\alpha = \alpha' - \beta'_1 \cdot \left(a_{11} \cdot \frac{\mu_W}{\sigma_W} + a_{12} \cdot \frac{\mu_H}{\sigma_H} + a_{13} \cdot \frac{\mu_{BMI}}{\sigma_{BMI}}\right) - \beta'_2 \cdot \left(a_{21} \cdot \frac{\mu_W}{\sigma_W} + a_{22} \cdot \frac{\mu_H}{\sigma_H} + a_{23} \cdot \frac{\mu_{BMI}}{\sigma_{BMI}}\right)$$

$$\beta_W = \beta'_1 \cdot \frac{a_{11}}{\sigma_W} + \beta'_2 \cdot \frac{a_{21}}{\sigma_W}$$

$$\beta_H = \beta'_1 \cdot \frac{a_{12}}{\sigma_H} + \beta'_2 \cdot \frac{a_{22}}{\sigma_H}$$

$$\beta_{BMI} = \beta'_1 \cdot \frac{a_{13}}{\sigma_{BMI}} + \beta'_2 \cdot \frac{a_{23}}{\sigma_{BMI}}$$

By substituting the numerical values obtained and reported in the tables 6 and 7.

Table 6. Mean and standard deviation to be used in the standardization of anthropometric parameters.

	Weight	Height	BMI
mean	50.68	161.01	18.43
sd	14.57	15.98	2.31

Table 7. Regression results.

	Estimate	Std.Error	pvalue
α'	12.933	0.024	<0.0001
β'_1	1.312	0.015	<0.0001
β'_2	0.0687	0.045	<0.0001

($\boldsymbol{n = 2347,\ Rsquared = 85.1\%,\ se = 1.16}$)

And hence the explicit numerical relationship, which identifies the morphological age:

$$morphological\ age_i = -3.614 + 0.058 \cdot w_i + 0.075 \cdot h_i + 0.081 \cdot\ bmi_i \qquad (5)$$

This weighting of the athlete’s anthropometric characteristics allows us to evaluate the expected average age, or what we have proposed as the morphological age (MA). Obviously, it is not possible to use this extrapolation weighting by applying it to athletes whose age does not fall within the observation range.

We have left the calculation passages indicated so that others can reproduce them for other sports in which young athletes often emerge and are selected not so much for real, better characteristics than their respective peers, but for the fact that they are in an advantageous situation given by early development.

Table 8. CPMA parameters.

α	β_W	β_H	β_{BMI}
-3.614	0.058	0.075	0.081

GSRIE: the weighting of sprint, jump (CMJF) and agility tests

To propose a more complete and objective evaluation, a longitudinal representation of the trend relative to the GSRIE (Gold Standard Range Improvement Expective) has been elaborated regarding the acceleration values (20m) of jump (CMJF) and agility achieved in the age groups under study.

Percentiles that can be used for test evaluations

The test results were normalized and weighted by morphological age by assigning a score in percentiles in order to contain, in evaluating young people with the same CA, any influences on performance due to different profiles of biological maturation. To incorporate the variability present in the age groups considered, the percentiles have been attributed by “bands”, column 8, for example, is to be understood as percentiles of the scores observed between 7 and 9 years, column 9 between 8 and 10 years and so on. For this reason, we do not report a column 7, and without losing generality, we include in column 17 those (few) eighteen-year-olds.

The morphological age thus obtained can then be used (in our opinion more correctly than the chronological age) to evaluate the performance of athletes in this delicate phase of their development. In this study, the over 2400 assessments collected were used to build the table 9,10 and 11 where the scores indicated in the last column can be obtained by simply finding the intersection between the age column and the row indicating the performance to be assessed.

Table 9. Percentiles of the acceleration test (20m, sprint).

8	9	10	11	12	13	14	15	16	17	Score
3.53	3.45	3.33	3.24	3.13	3.04	2.99	2.94	2.91	2.91	**95**
3.63	3.52	3.41	3.32	3.21	3.11	3.03	2.98	2.95	2.94	**90**
3.67	3.58	3.47	3.38	3.25	3.15	3.06	3.00	2.98	2.96	**85**
3.70	3.62	3.51	3.42	3.30	3.18	3.09	3.03	3.00	2.98	**80**
3.74	3.65	3.55	3.45	3.33	3.21	3.12	3.05	3.01	3.00	**75**
3.79	3.67	3.58	3.48	3.36	3.25	3.14	3.07	3.03	3.02	**70**
3.81	3.70	3.60	3.51	3.41	3.27	3.17	3.08	3.05	3.04	**65**
3.83	3.74	3.63	3.54	3.43	3.31	3.19	3.10	3.06	3.05	**60**
3.85	3.76	3.65	3.57	3.47	3.34	3.21	3.12	3.08	3.06	**55**
3.89	3.79	3.68	3.59	3.50	3.37	3.24	3.14	3.09	3.08	**50**
3.94	3.81	3.70	3.61	3.52	3.40	3.26	3.16	3.10	3.10	**45**
3.97	3.84	3.73	3.63	3.54	3.43	3.29	3.18	3.12	3.11	**40**
4.00	3.87	3.76	3.66	3.58	3.46	3.32	3.20	3.14	3.14	**35**
4.03	3.91	3.79	3.69	3.61	3.49	3.35	3.22	3.16	3.16	**30**
4.08	3.95	3.82	3.72	3.63	3.52	3.38	3.25	3.18	3.18	**25**
4.13	3.99	3.85	3.75	3.67	3.57	3.42	3.28	3.21	3.20	**20**
4.18	4.05	3.89	3.79	3.70	3.61	3.48	3.32	3.23	3.23	**15**
4.23	4.12	3.94	3.84	3.76	3.65	3.53	3.37	3.27	3.26	**10**
4.37	4.20	4.04	3.91	3.84	3.73	3.62	3.45	3.32	3.31	**5**

Note. percentiles by age

Table 10. Percentiles for the jump test (CMJF)

8	9	10	11	12	13	14	15	16	17	Score
19.8	20.6	22.6	24.3	25.2	27.4	29.6	33.3	35.0	36.0	**5**
20.8	21.9	23.8	25.3	26.6	28.5	31.5	34.8	37.2	37.6	**10**
21.6	23.1	24.6	26.2	27.9	29.7	33.0	36.4	38.0	38.1	**15**
22.1	23.5	25.3	26.8	28.2	30.9	33.9	37.2	39.0	38.7	**20**
22.9	24.3	25.9	27.4	29.2	31.6	34.8	38.2	39.8	39.1	**25**
23.2	24.9	26.5	28.0	29.7	32.5	35.6	39.0	40.2	40.4	**30**
23.8	25.3	26.8	28.6	30.3	33.3	36.4	39.7	40.7	41.1	**35**
24.2	25.8	27.3	29.1	31.0	34.0	37.2	39.9	41.5	42.0	**40**
24.6	26.5	28.0	29.4	31.8	34.8	38.2	40.7	42.0	42.4	**45**
25.2	26.8	28.5	30.2	32.5	35.6	38.9	41.1	42.5	43.3	**50**
25.8	27.3	28.7	30.9	33.3	36.3	39.7	41.5	43.3	43.7	**55**
26.5	27.7	29.4	31.4	33.9	37.2	40.3	42.4	43.7	44.1	**60**
26.6	28.1	30.2	31.8	34.8	38.2	40.7	43.3	44.3	44.6	**65**
27.2	28.7	30.9	32.6	35.6	39.0	41.5	43.7	45.0	45.2	**70**
27.9	29.4	31.6	33.4	36.4	39.9	42.4	44.3	45.8	46.1	**75**
28.6	30.2	32.3	34.7	37.5	41.0	43.3	45.2	46.5	46.5	**80**
29.4	31.0	33.3	35.6	38.9	42.4	44.3	46.1	47.9	47.9	**85**
30.7	32.1	34.7	36.8	40.7	43.3	45.8	47.7	49.0	49.5	**90**
32.0	34.0	36.4	39.3	43.1	45.0	47.7	49.7	50.7	50.7	**95**

Note. percentiles by age

Table 11. Percentiles for the agility test

8	9	10	11	12	13	14	15	16	17	Score
7.57	7.44	7.22	7.01	6.83	6.69	6.59	6.50	6.45	6.43	**95**
7.71	7.55	7.34	7.13	6.93	6.79	6.67	6.57	6.51	6.50	**90**
7.84	7.61	7.42	7.23	7.02	6.87	6.73	6.63	6.56	6.55	**85**
7.95	7.70	7.48	7.30	7.09	6.91	6.78	6.67	6.59	6.57	**80**
8.00	7.79	7.54	7.36	7.15	6.96	6.82	6.71	6.64	6.61	**75**
8.06	7.84	7.60	7.41	7.21	7.01	6.86	6.75	6.67	6.63	**70**
8.12	7.91	7.65	7.45	7.27	7.07	6.90	6.79	6.71	6.67	**65**
8.21	7.96	7.70	7.51	7.33	7.11	6.93	6.81	6.74	6.70	**60**
8.25	8.00	7.74	7.56	7.36	7.17	6.98	6.84	6.77	6.75	**55**
8.30	8.05	7.80	7.61	7.40	7.21	7.01	6.88	6.80	6.79	**50**
8.38	8.12	7.85	7.65	7.44	7.26	7.07	6.91	6.83	6.81	**45**
8.46	8.19	7.92	7.70	7.49	7.31	7.11	6.95	6.85	6.84	**40**
8.49	8.24	7.96	7.74	7.54	7.35	7.17	6.98	6.89	6.88	**35**
8.57	8.31	8.01	7.80	7.60	7.39	7.22	7.01	6.93	6.91	**30**
8.63	8.39	8.07	7.87	7.67	7.44	7.28	7.08	6.96	6.95	**25**
8.71	8.47	8.15	7.92	7.72	7.51	7.32	7.14	6.99	6.98	**20**
8.84	8.56	8.24	7.98	7.78	7.59	7.38	7.21	7.08	7.03	**15**
9.00	8.67	8.34	8.08	7.91	7.68	7.45	7.28	7.15	7.10	**10**
9.29	8.90	8.49	8.21	8.01	7.80	7.61	7.38	7.27	7.21	**5**

Note. percentiles by age

Following the previous considerations, let's us go back to the scores of the athletes shown in the table and see how to evaluate their performance, which can calculate by applying (5), we obtained in table 12.

Table 12. Performance evaluation example.

athlete	chronological age	weight (kg)	height (cm)	time (sec)	morphological age	score
id1	11.0	28.3	139.0	3.7	9.61	54
id2	11.0	37.2	147.0	3.7	10.93	27
id3	11.1	28.4	133.0	3.7	9.28	51
id4	8.9	28.4	134.4	3.7	9.36	52

From these results, we can see that the athletes id1 and id2 are judged very differently despite having the same age and almost the same times in the tests, while athletes id3 and id4 despite having different times and two-years difference in age (personal data), almost reach the same score.

The figures 8,9 and 10 allow you to determine the expected performance for each individual athlete, allowing you to track individual performance trends.

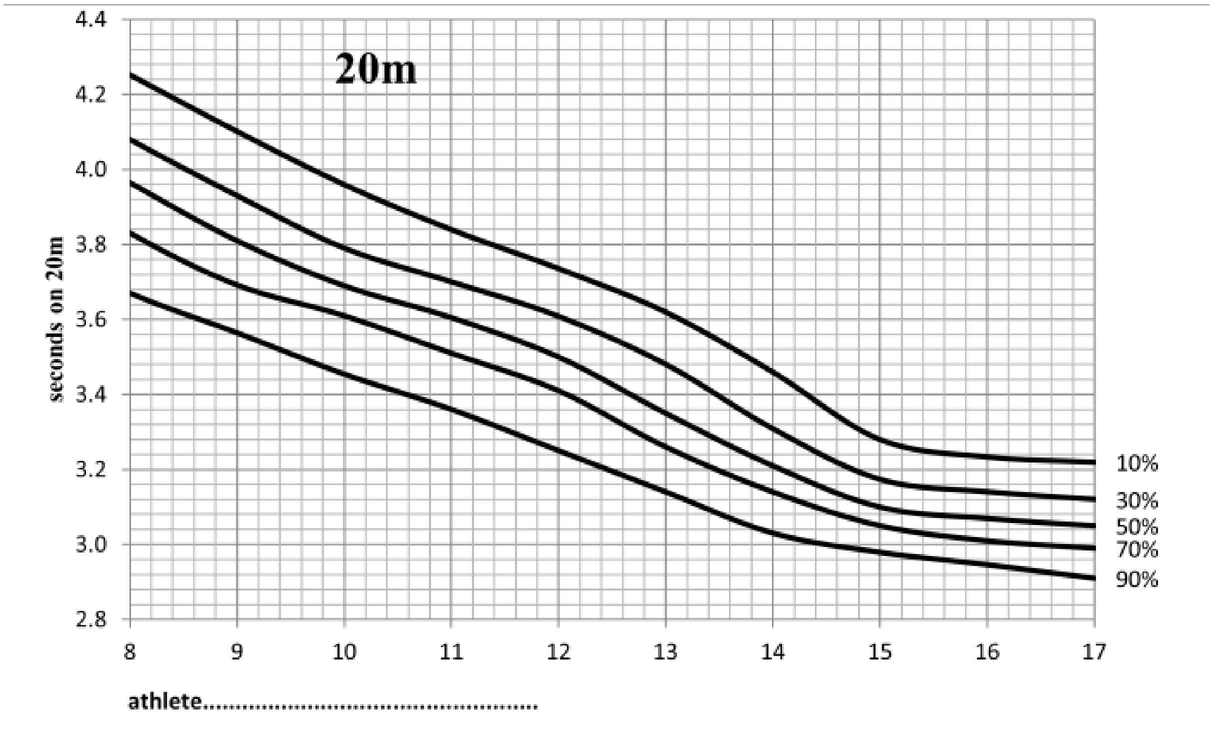

Figure 8 Longitudinal trend of the expected performance over 20m

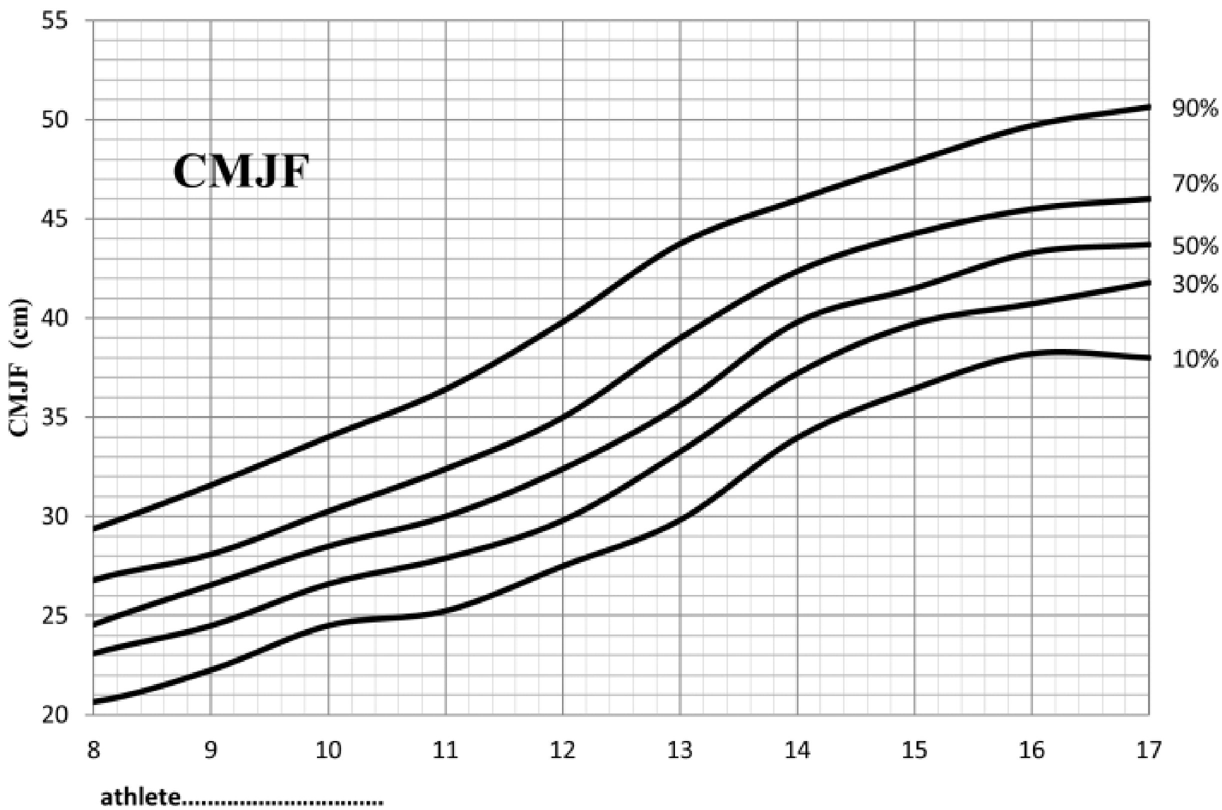

Figure 9 Longitudinal trend of the expected performance over CMJF

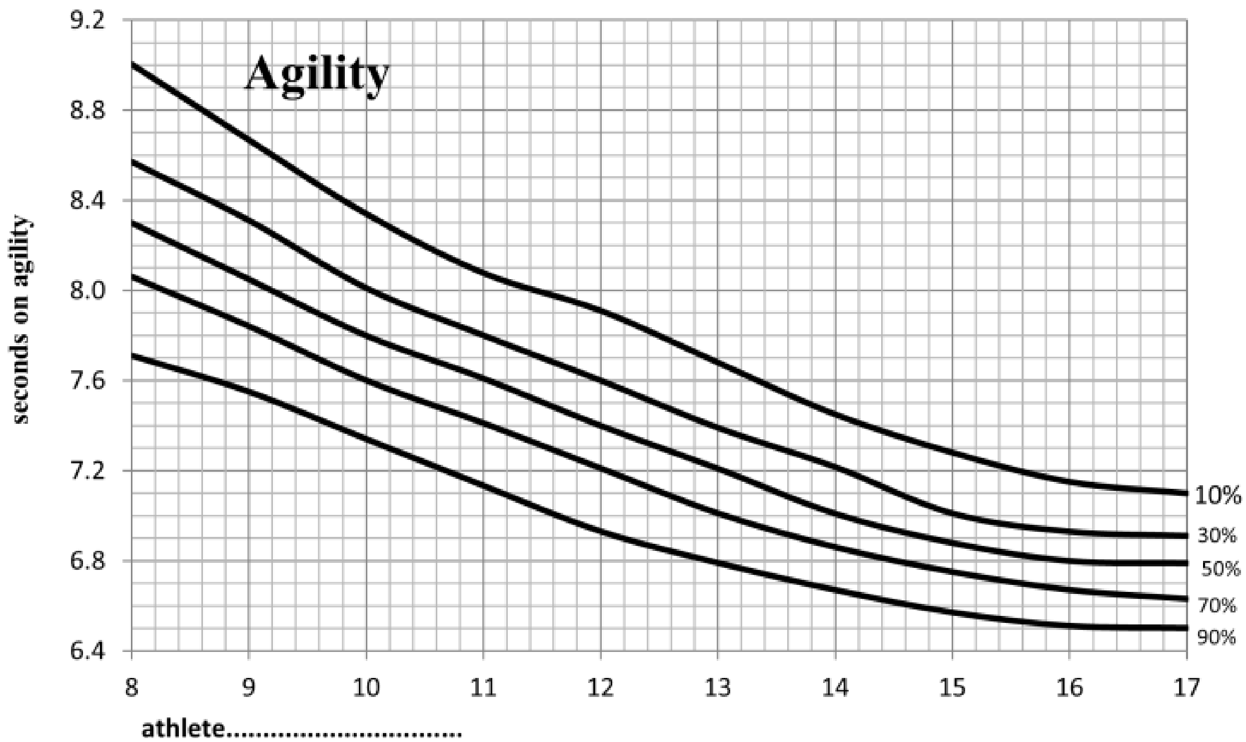

Figure 10 Longitudinal trend of the expected performance over Agility

Use of graphs for longitudinal monitoring of performance compared to expectations.

Let us consider, for example, a 9-year-old boy, who records a time of 3.8 seconds in the 20m event his “expected” performances will be those indicated by the red line in the figure 11, thus providing a reference for what may be improvements or worsening compared to “his” expected standards. Generally, when the improvements obtained on a test are EI, they tend to be the result of a set of factors including genetic predisposition, well-planned and well-dosed workouts in which the dose/response ratio was optimal and last but not least the possibility of being in a favorable psychophysical context. In this regard, the “timing” of the stimulus should not be underestimated, in other words is the possibility of taking advantage of the most appropriate moments for the best psychobiological response for that specific physical quality.

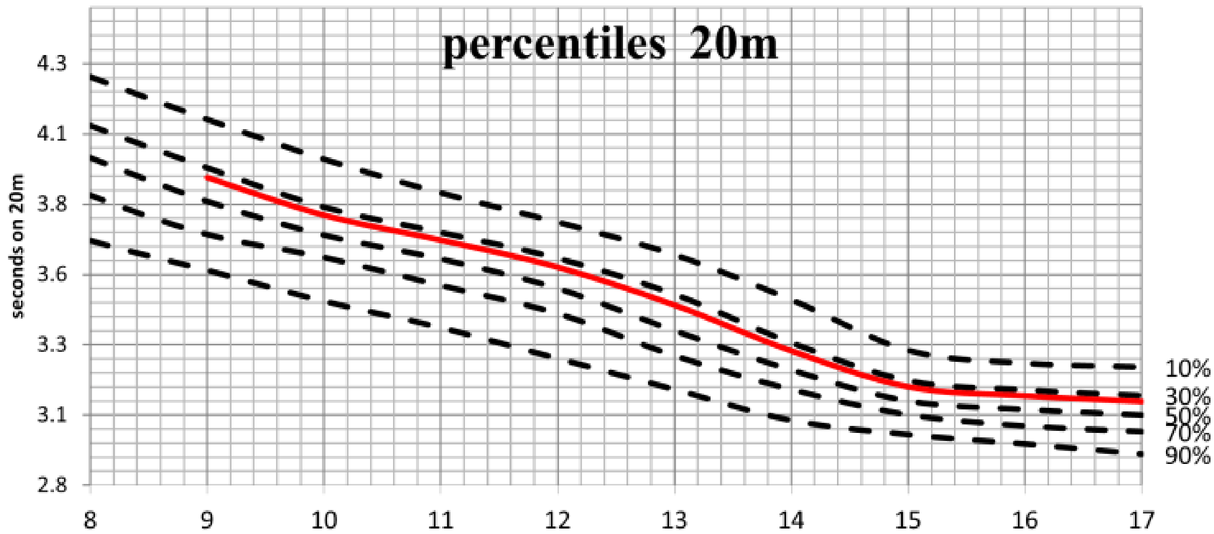

Figure 11 Use of graphs to predict expected performance.

Improvements expected by age group

We have always wondered, when dealing with young athletes, if there is a way to understand if the improvement obtained in the tests mainly corresponds to the performance boost provided by the normal maturation process or if it is to be considered as an adaptive response. to the training stimulus. The values were detected among athletes who carried out two consecutive measurements spaced out over a 9-month period and for less than 15 months, and then comparing the result to one year. In other words, we have considered, without loss of generality, a linear variation in the various time intervals. The steps indicated are better explained in the table 13, which can be simply implemented using any spreadsheet.

Table 13. Calculation of absolute and percentage improvement corrected for age variation.

id	date of birth (A)	test date (B)	chronological age (C)	age class D)	agility (sec) (E)	absolute age variation (F)	absolute change in performance (G)	correction of performance improvement (H)	percentage (corrected) improvement (I)
1	21/05/2001	15/02/2018	16.75	16-17	7.1				
2	21/05/2001	30/04/2019	17.95	17-18	6.7	1.20	-0.04	0.0333	5%

Where: C1 = B1-A1; F2 = C2-C1; G2 = E2-E1; H2 = -G2/F2 (*); I2 = H2/E2*100%. (*) The minus sign is due to the fact that in speed tests there is an improvement when the time measured is less than that of the previous test.

The tables 14 and 15 (and corresponding figures 12,13 and 14) report the average values by age group regarding improvements in 20m times, and agility and centimetres gained in jumping (CMJF). In the first (table 15) you can find the improvements in absolute terms, while the second (table 16) shows the values expressed in percentage terms.

Table 14. Average improvements expected by age class.

	Absolute improvement		
	CMJF (cm)	**Agility (sec)**	**Speed (sec)**
8-9	3.12+/-3.52 (15) **	0.40+/-0.63 (13) *	0.27+/-0.24 (14)**
9-10	1.80+/-4.02 (34) *	0.51+/-0.37 (28)**	0.15+/-0.21 (31)**
10-11	1.00+/-3.33 (81)**	0.32+/-0.31 (67)**	0.12+/-0.17 (76)**
11-12	1.89+/-4.93 (106)**	0.30+/-0.35 (105)**	0.11+/-0.17 (100)**
12-13	2.18+/-4.3 (164)**	0.28+/-0.35 (157)**	0.07+/-0.19 (161)**
13-14	1.81+/-4.09 (136)**	0.26+/-0.32 (120) **	0.06+/-0.18 (134)**
14-15	2.52+/-3.79 (136)**	0.27+/-0.32 (125)**	0.11+/-0.18 (136)**
15-16	2.14+/-4.19 (102)**	0.28+/-0.27 (94)**	0.11+/-0.15 (100)**
16-17	1.55+/-3.88 (88)**	0.23+/-0.24 (80)**	0.09+/-0.14 (85)**
17-18	1.20+/-3.33 (72)**	0.14+/-0.29 (68)**	0.06+/-0.12 (70)**

Note. All the mean improvements observed are significantly different from zero (t-test, ** p value <0.01, *p value<0.05). Data are expressed as mean+/-st.dev. (n.obs)

Table 15. Percentage average improvements expected by age class.

	Percentage improvement		
	CMJF (%)	**Agility (%)**	**Speed (%)**
8-9	12.8+/-13.9	4.5+/-6.9	6.48+/-6.54
9-10	7.3+/-15.5	6.4+/-4.7	4.48+/-5.03
10-11	5+/-11.8	3.9+/-3.9	3.58+/-4.07
11-12	5.8+/-14.8	3.9+/-4.6	3.05+/-4.81
12-13	6.6+/-13.6	3.8+/-4.8	2.4+/-5.23
13-14	5.3+/-11.5	3.5+/-4.4	2.12+/-4.81
14-15	6.2+/-9.9	3.9+/-4.7	3.68+/-5.14
15-16	5.5+/-9.6	4+/-3.9	3.91+/-4.41
16-17	4.3+/-9	3.4+/-3.6	2.9+/-4.24
17-18	2.8+/-6.9	2.2+/-4.3	2.02+/-3.93

The figures12 – 14 show the trend over the years in improvements in absolute and percentage terms in the three tests. The error bars are given by mean + standard error of the mean.

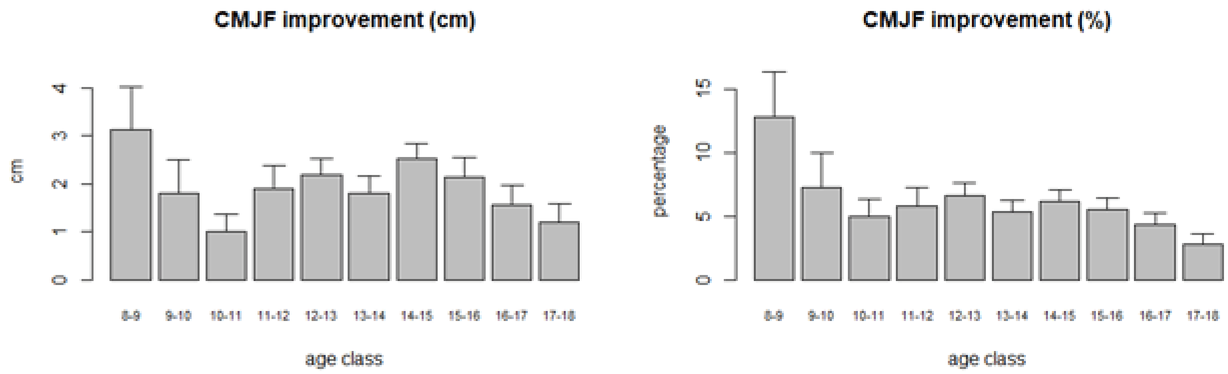

Figure 12 Jump test improvement

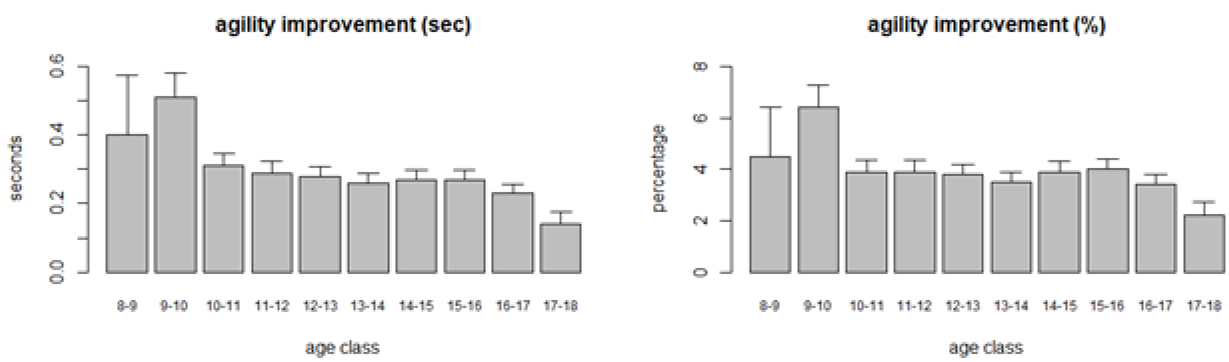

Figure 13 Agility test improvement

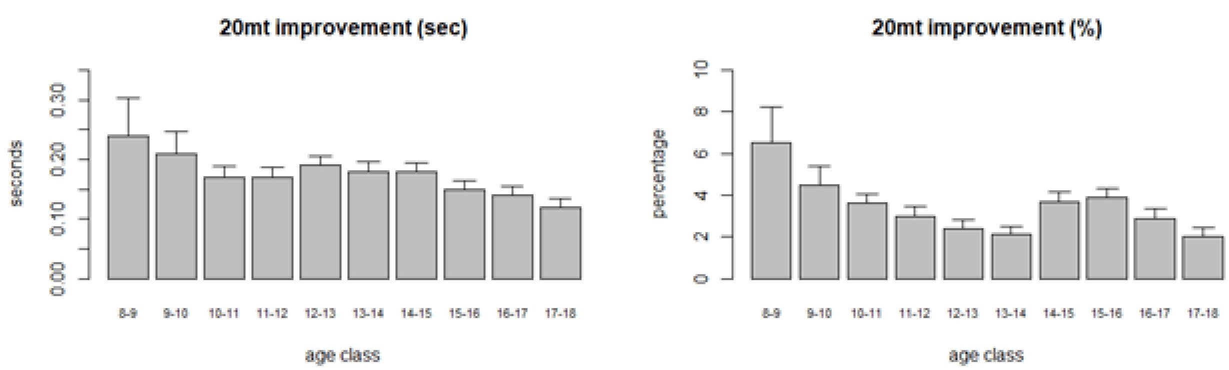

Figure 14 Speed test improvement

Finally, considering only those athletes for whom all three performances have been recorded, we can extrapolate a general quantification of the percentage improvements, by calculating a geometric mean of the percentage improvements for the individual trials. The results are shown in table 16 and figure15.

To better interpret any improvements obtained in the jump, agility and sprint tests, it is necessary to start by considering the Gold Standard Range Expective (GSRE) obtained for each of the tests considered (table 14). The GSRE is essential if you want to understand if the improvement recorded in a test fall within the range of a statistically expected improvement, i.e., R.I. (Regular Improvement) or is different from this and therefore can be classified as I.I. (Irregular Improvement)

Interesting-in this regard- is the study by C. Saward et al. 2020 in which the development model in players who later became professionals was verified compared those who remained amateurs, in relation to the ability to jump (CMJF) and to agility. From the age of 12, a significantly higher improvement rate was observed only in those who became professional footballers.

Table 16. Overall average percentage improvement (GSRE).

Average expeted improvement			
8-9	7.1% +/- 6.4% (12)	13-14	3.6% +/- 5.0% (109)
9-10	5.8% +/- 7.0% (28)	14-15	4.5% +/- 4.7 % (123)
10-11	4.0% +/- 4.5% (62)	15-16	4.3% +/- 4.0% (90)
11-12	4.2% +/- 5.8% (87)	16-17	3.4% +/- 3.6% (74)
12-13	4.1% +/- 5.1% (145)	17-18	2.2% +/- 3.5% (61)

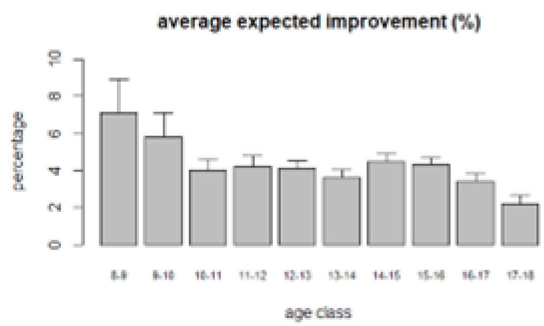

Figure15-Average expected percentage improvement (GSRE)

DISCUSSION

The longitudinal distribution of the measures of weight and height relative to the sample of about 2.400 young sportsmen of a Swiss Super league club aged between 7 and 17 years, showed (Figures 2 and 3) how the APHV (age of peak health velocity) and APWV (age of peak weight velocity) both occur within the 12-13 year range with an average gain of 6.5 ± 2.4 cm for height and 6.3 ± 2, respectively , 8 kg for the weight. What has been observed would suggest that APHV and APWV are one year earlier than what other authors have found in young people with the same CA even if they are not “elite” sportsmen. This feedback inevitably leads to reflections on how the criteria adopted in the youth sectors obviously tend directly or indirectly to favor the selection of more mature young people. Compared to subjects with late maturation, these have on average, better athletic performance. Doing so runs the risk of penalizing late subjects who are unlikely to be guaranteed a sufficiently long observation period consistent with their different kinetics of development.

It is necessary to identify selection methods that are, also related to the evaluation of technical-tactical skills, and more accurate and more correlated with the real determinants of game skills. In any case, the assessment of physical qualities or activities closely related to them should always be weighted according to the degree of maturation.

It is known by Malina et al. 2004 (15) how, in the developmental phase, the improvements recorded in young people, in particular those relating to the development of physical qualities, depend on how the training process (loading dose) integrates with the normal evolutionary drive, there by generating a certain adaptive response in the structure of the young person. The adaptive response acts specifically on each physical quality by varying its training potential to a heterogeneous extent following an undulatory trend. It is interesting that this training potential is not constant, but changes according to the appearance and disappearance of the so-called “sensitive phases”, that is the particularly favorable moments of development, in which, for the same amount of training administered, an adaptive response is obtained that allows room for improvement in physical qualities.

The existence of sensitive phases, in relation to different physical qualities, has already been documented in the normal school youth population by Gallahue et Ozmun in 2006 (5), perhaps a little less so regarding young sportsmen from professional clubs.

One of the objectives of this study was to understand when and to what extent the sensitive phases influence, the ability to accelerate, jump and have agility in the period from 7 to 17 years. This would allow for a more targeted programming, in harmony with the training proposals and, respecting the timing with which the appearance and disappearance of the moments deemed most favorable for insisting on one type of training as opposed to another. With this premise it is easy to understand how much crucial the training planning (selection of contents) and the quantification of the training load (TL) in fully exploiting the advantages of being close to the appearance of a favorable moment.

Furthermore, it should be noted that proper content planning must be correlated with the refinement of the management of sensory inputs and proprioception, determining factors for effective and efficient movement control. Another aspect to consider is that the physical structure of the young person, being subject to continuous morphological changes, requires sense-perceptive adjustments that entail, net of the demands of football, a considerable and often underestimated supplementary cognitive commitment.

The favorable moments coincide with the age groups in which the performance variations are close to the value corresponding to the best result or the ABAEI (Age Best Average Expected Improvement). As for the control of the training load, we know that more than directly influencing the improvement of neuromuscular qualities, it can, especially if excessive and concentrated over a short time, predispose an individual to the onset of injuries, typical of growth, that cause limitations, and in some cases interrupt the sporting activity of the young player.

The trend of the results obtained in the interval from 8 to 18 years interval showed (table 18), a constant statistically significant improvement (t-test, p value <0.001) of the results obtained in all three types of tests (CMJF, 20m, Agility).

The percentage improvements in the tests (table16) remained constant throughout the development process (from 9 to 18 years) despite notable changes in the weight and height of the subjects. Notwithstanding, the morphological changes inevitably induce a reprogramming of movement skills as a physiological response of adaptation to the variations in length of the continuously growing anatomical segments.

To date, it has always been difficult to interpret test results such as, those we have proposed, since it is rather difficult to understand how much an improvement is part of the normal development process and how much of is influenced by the training performed. From this point of view, the determination of the Gold Standard Range Expective (GSRE) obtained for each of the tests considered (tables 16-17) could be a step forward in understanding the nature of the improvement. The improvement detected in a single player, after two test sessions, should be considered an R.I. (Regular Improvement) when it falls within a normal range, that is, considering, as usual, a confidence level of (approximately) 95%, given by the average ±2*st.dev. It is defined as I.I. (Irregular Improvement) when it falls outside the expected range.

We also quantified the “joint” improvement, considering the geometric mean of the improvements in the three types of tests, for those athletes who performed all three for two consecutive surveys as previously described, we found that these were higher in the 8-9 years-olds age groups with 7.1 (± 6.4) % and 9-10 years –olds with 5.8 (±7) %.

Considering instead the ABAEI for each of the three tests (CMJF, 20m, Agility), (table16). In the 8–9-year-old range, the highest improvement was obtained in the CMJF test with an average gain of 12.8 (± 13.9) %. Following this, again in the jump event, the 9–10-year-old group achieved an average improvement of 7.3 (± 15.5) %. As regards the agility test, ABAEI was detected in the 9–10-year age group with an average increase of 6.4 (± 4.7) % while in the 20m event in the 8–9-year range there was an average increase of 6.5 (± 6.5) %. Observing the kinetics of the improvements related to the three tests, we observed both in jumping and in agility, starting from 10 years of age up to 17-18, an average constant increase including between 2.8 and 6.6% in the CMJF, between 2.2 and 3.9% in the agility, and between 2.02 and 3.58% in the speed. Analyzing the data collected, year after year, an improvement in performance is observed in all three tests considered, in particular in the 20m test. Starting from the 8–9-year-old range, a marked “decalage” of earnings is noted which, progressively, decreases up to 13-14 years of age. We pass from average earnings equal to 6.48%, at 8-9 years of age, to progressively more contained earnings in the subsequent age groups up to 13-14 years of age, when the gain of 2.12% is achieved.

Subsequently, between 14 and 16 years of age, there seems to be a decisive recovery in earnings, which rises to around 4% subsequently halving at 17-18 years of age up to the minimum value of 2.02%.

Starting from these data, as regards the 20m sprint, two moments in particular seem more "sensitive" and therefore susceptible to improvement: the period from 8-11 years of age and the period from 14-16. In the period from 11-14 years of age there is a slowdown in performance, probably explained by the achievement of the PHV. However, having noted that in all three types of tests, ABAEI falls within the 7–10-year period, this suggests how often these improvements occur, not surprisingly, during a period particularly sensitive to "skills learning", which is a moment of growth in which young people, much more than at other times, are particularly predisposed to learning quickly.

The constant improvements obtained in the three types of tests can be traced back to an increased neuromotor efficiency. This is explained by a better management of movement during the running and jumping phases, and by the gain in strength and speed influenced by the stature and weight growth in which, around the PHV, an elongation of the bone levers occurs together with a progressive increase, 1-2 years post PHV, of muscle volume. These improvements seem to be influenced above all by the degree of motor coordination on which the timing of the supports in the running and jumping phases, which is strictly influenced by the ability of inter-segmental control, and therefore of the vertical (postural alignment), and by the combination and adaptation of the movements. The ability to know how to run fast and jump, especially in pre-pubescent young people with normal or late maturation, seems to depend more on the neuromotor potential than on the growth of lean mass. Raising neuromotor potential in young people predisposes them to learn complex movement patterns faster. Evidently, those who have a high neuromotor potential lose their degree of motor coordination to a much lesser extent during the development phases, in the sense that they adapt more quickly to morphological changes.

The ability to adapt to the complexity of movement has a strong cognitive connotation, as it requires sensory-perceptive speed, a quality necessary to find efficient movement strategies in a context of "change" and a certain degree of body awareness essential for:

1. knowing how to breathe adequately, harmonizing diaphragmatic expansion and contraction with the support and thrust phases of the feet, limiting the tension on the shoulders and thus ensuring good freedom of movement of the limbs, thanks also to an optimal blood perfusion of the muscles involved.

2. knowing how to adapt quickly by facing any type of change with courage, accepting it as a challenge for competition with and not as a pretext for giving up.

3. knowing how to manage emotions while remaining rooted in the "here and now" and while leaving the comfort zone, it still manages to evolve in complexity.

Another aspect to consider is the ability to stabilize the core or the structure that supports the force vectors during the running phases, guaranteeing greater freedom of movement and efficiency (in the support / push phases) by the upper lower limbs. This evaluation has a threefold value:

1. projective, since it explains, immediately after carrying out the jump acceleration and agility tests, how the values obtained are placed with respect to the distribution of the data of those who with the same physical structure (MA).

2. predictive, because it allows you to make a forecast of how the performance detected at a certain moment could subsequently evolve in the medium, and long term regardless of the context and the training stimulus.

3. preventive, since it allows you to investigate any physical problems, for example the presence of dysfunctions of the osteo-articular or skeletal muscle system if there is no improvement, or when the gain is reduced compared to that expected.

Some studies and in particular that by Gustavo Claudino et al. in 2016 (7) highlighted a possible relationship between a decrease in the average value of jumping tests and a decrease in neuromuscular efficiency. Finally, it should be noted that the annual improvements obtained by a young “elite” sportsman in the tests that investigate physical qualities, such as those explored here, are not easy to interpret, as it is necessary to distinguish how much they are due to the evolutionary drive (sensitive phases) and how much to the adaptive response of the young person to the training load. This study aims to bring some clarity to these considerations.

CONCLUSIONS

The collection and analysis of data carried out on several tens of young elite footballers, aged between 7 and 17, made it possible to verify and trace, from infancy to adolescence, the anthropometric evolution of the elite young football player along with the trend of some neuromuscular characteristics known as the ability to jump, the ability to accelerate and the ability to show agility. Each of these was weighted in relation to the morphological age of each. The trend of the anthropometric data relating to the sample observed showed an anticipation of the achievement of both the PHV and the PWV, suggesting that the selection criteria adopted have tended to favor individuals with early maturation.

Data processing using a statistical analysis model (CPMA model) was necessary to obtain an indirect evaluation that estimated the degree of physical development in particular the morphological age starting from the detection of simple anthropometric measurements. The estimate of the morphological age-proposed in this study-is added to other indirect criteria for measuring the degree of maturation which are well known and have already been validated such as those proposed in 2002 by Mirwald et al. (22). This can be considered an interesting contribution to approaching the actual biological age of young athletes. These assessments of biological age, albeit indirect and therefore less precise are nevertheless unanimously preferred to radiological tests (those provided for the determination of bone age) partly for economic reasons but above all because they avoid subjecting young athletes to dangerous radioactive tests (rays x).

During the observed period from 7-17 years of age the results of the tests carried out (CMJF, Sprint and Agility) have almost always shown a significant increase in performance. However, while for the jump test (CMJF) and agility tests the increase was constant, in the case of the 20m sprint test the improvement trend seems to have been more conditioned by the stature growth since the lower percentage improvement (2.02%) coincided precisely with the age close to the PHV (13-14 years) while the higher one seems to correspond to the moments away from the PHV (8-11 and 14-16 years) in which the improvements detected in 20m event are, practically doubled (<4 – 6.48%>).

To know when the improvement of each neuromuscular quality was particularly favorable and to know the range of physiological improvement that we could expect, from one year to the next, during the observed time span (7-18 years of age) it was necessary to calculate the ABAEI (Age Best Average Expected Improvement) and the GSRE (Gold Standard Range Expective).

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