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ORIGINAL

PHYSICAL ABILITY OF THE YOUTH FOOTBALL PLAYERS OF A PROFESIONAL CLUB

CAPACIDADES FÍSICAS EN JUGADORES DE FÚTBOL FORMATIVO DE UN CLUB PROFESIONAL

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ABSTRACT

Physical characteristics are extremely varied in football, but the ability to produce high-intensity efforts and delay fatigue as much as possible in intermittent efforts is very important. There are several studies that analyse these characteristics in professional football but there are fewer that analyse the individual training categories. This study analyses changes for jumping, speed, agility and specific aerobic endurance in footballers of the youth teams of a professional club that plays in the Spanish league. There was an increase in performance level with age, although no significant differences in close age groups were observed, with a plateau in performance in explosive strength and acceleration being noted from 17 years of age and a plateau in speed and agility from 15 years of age.

KEYWORDS: Football, Youth Players, Speed, Jumping, Agility.

RESUMEN

Las características físicas del fútbol son muy diversas, aunque se reconocen como muy importantes la capacidad de realizar esfuerzos de alta intensidad y la de retrasar la fatiga en la mayor medida posible en esfuerzos intermitentes. Son diversos los trabajos que analizan dichas características en el fútbol profesional, aunque son menores los que analizan las categorías de formación. En el presente estudio se analiza la evolución por categorías de pruebas de salto, velocidad, agilidad y resistencia aeróbica específica, en jugadores de fútbol jóvenes de la cantera de un club profesional de la liga española. Se produjo un incremento de las marcas con la edad, aunque no se observaron diferencias significativas en grupos de edad cercanos, produciéndose una meseta en el rendimiento en la fuerza explosiva y velocidad de aceleración a partir de los 17 años y en la velocidad de desplazamiento y agilidad a los 15 años.

PALABRAS CLAVE: Fútbol, Jugadores Jóvenes, Velocidad, Salto, Agilidad.

INTRODUCTION

Football involves a series of complex characteristics since it is a cooperation-opposition group sport played with open skills. Due to these and other characteristics, it is difficult to isolate and define the factors that determine success or maximum performance (Taskin, 2008). Without bearing in mind parameters such as good decisions or luck that may occur in a certain moment on the field of play, the final result will be conditioned by a set of factors, amongst which are individual and team performance, individual and team tactics and the performance of the opponent (Stolen et al., 2005). Precisely due to this complexity of factors, the physical, technical, tactical, psychological, biological and theoretical components are defined as areas that can be trained (Muñoz and Cruz, 1999, Paredes et al., 2011). The physical, physiological, psychological and other kinds of demands of this sport must be looked after. The study of each of them has helped develop the progressive relationship between science and football in the last few decades (Newton, 2006).

The physiological demands of the game are very diverse (Krustrup et al., 2005) and footballers have to deal with complex requirements (Rhea et al., 2009). The aforementioned physiological demands will vary notably in accordance with factors such as the player's position on the field of play (Erkmen, 2009, Sporis et al., 2009), the team's style, their ability level itself (Kaplan et al., 2009) and even environmental factors. On a predominant aerobic base the player has a key anaerobic component, with power, muscular endurance, flexibility and reactions also found to be very important (Sotiropoulos et al., 2009).

The adequate physiological profile in professional footballers has the fundamental aim of identifying their strengths and weaknesses (Caldwell and Peters, 2009). Nevertheless, research of these factors in lower level players and players of different ages are not very abundant (González et al., 2011), and as such, we cannot establish a solid physiological profile. Amongst the aforementioned research, we can highlight the comparative anthropometric studies in footballers of Hetzler et al., (2010) or Meylan and Malatesta (2009), on plyometric training in young football players or the repeated work of Meckel et al., (2009), which established an interesting relationship between aerobic and anaerobic performance in speed tests in teenage footballers. Gravina et al., (2008) and subsequently, Wong et al., (2009) both searched for the relationship existing between anthropometric and physiological factors in football players under 14 years of age. Furthermore, Kaplan et al., (2009) show us the high importance of speed and agility as factors of success in football. In any case, a greater number of major studies that provide clear data from results of specific tests that are objective, reliable and valid is necessary.

The aim of this study is to assess and analyse the explosive strength, speed and aerobic endurance of teenage and semi-professional footballers by their age and level.

MATERIAL AND METHOD

Sample

We studied teenage and semi-professional youth players of Córdoba C.F. S.A.D., who play in the Spanish second division. The study was approved by the ethics committee of the Universidad de Córdoba and all participants provided their informed consent. All players were considered healthy, without previous disease and had not been injured in the 2 months prior to the tests.

Subjects

118 males were assessed (Table I). The under 14s and under 16s trained 4 times a week and the under 19s and semi-professional team carried out 5 training sessions per week in their respective teams, in addition to matches.

Weight and height

Weight was measured to an accuracy of 0.1kg., and height was measured in centimetres; both were carried out with *Seca scales and stadiometer* (Hamburg, Germany).

Age

Four categories were established by age, in accordance with the titles given by the Royal Spanish Football Federation: Semi-professionals – players 20 years of age or older, under (U)19s – from 19 to 17 years old, U16s – players of 16 or 15 years of age, U14s, players of 14 or 13 years of age, all having the abovementioned ages from 1 January of the season in question. The titles of the categories are: U19s, U16s and U14s; the semi-professional team competed in the Spanish national third division.

Table I. Basic characteristics of the sample

	U14 (N=20)	**U16** (N=37)	**U19** (N=40)	**Semi-professional** (N=19)	* one-way ANOVA
Age	14.02□0.27	15.45□0.50	17.55□0.80	21.31□1.05	0.000
Years practised	5.62□0.12	7.09□0.16	9.15□0.12	12.04□0.34	0.000
Height	169.8□5.39	174.8□4.35	176.1□5.82	178.4□4.46	0.000
Weight	59.15□5.60	65.18□5.49	72.67□7.65	72.75□3.86	0.000

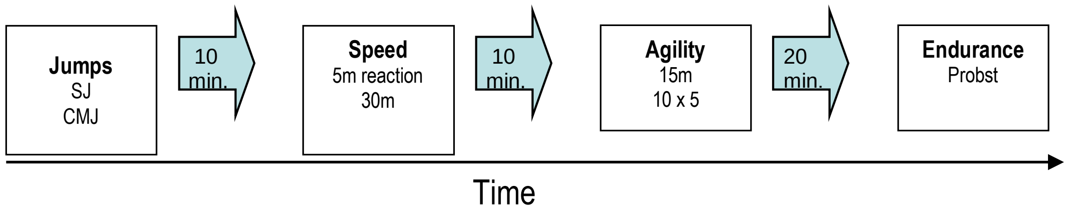
Procedures

After a minimum 48-hour rest after a training session or match, the physical condition tests described below were carried out (which were performed at a time in the season considered to be of high activity within their annual schedule).

Firstly, they completed a 15-minute warm-up, which consisted of various running exercises, joint mobility, short sprints and explosive actions involved in football, as is regularly established for all the youth teams in a similar fashion. The tests were performed in the following order: Firstly, explosive strength exercises: SJ (squat jumps) and CMJ (counter movement jumps), followed by speed tests: 5 metres with reaction and 30 metre sprints without reaction (in which speed is measured at 5, 10 and 30 metres). Next, the agility tests were performed: 15 metres and 10 x 5m. There was a recovery period of 5 minutes after each test. To finish, an aerobic power test was performed with a recovery interval of 20 minutes.

The physical tests were carried out on an artificial grass football pitch in the following order:

Figure 1. Order of tests



Functional tests

Jumping test

The jumping tests were carried out using the Ergojump Bosco-System (Bosco, 1983, Kotzamanidis, 2006, Vescovi et al., 2010).

Three jumps were recorded and the mean of the three was taken (Kotzamanidis, 2006). The players were familiarised with this type of jump and technically false jumps were excluded but they were allowed to attempt the jump again (Guillén et al., 2011).

Speed test

Running speed was measured over a distance of 30 metres, with intermediate intervals being determined at 0-5m, 5-10m, and 10-30m of the aforementioned sprint. Two attempts were carried out over a distance of 30m with a rest period of 3 minutes between each attempt. The best time of each interval or of the total was registered. Subjects were motivated to run as fast as they could and pass the 30m line without reducing their speed. The times were recorded to 0.001 seconds. DSD (Spain) photocells were used and placed at a height of 50cm above the start line and 5, 10 and 30 metres from the same. The subjects began their sprints 1 metre from the start line.

The 5-metre-reaction acceleration test was carried out, using a sound reaction system connected to the DSD (Spain) photocell software. Participants were allowed two attempts for each of the 5m reaction runs, carried out prior to the 30m test and with a rest period of 3 minutes between each attempt.

Agility test

Agility over 15 metres: It was carried out on a flat surface with two DSD (Spain) photocells placed at a height of 50cm above the ground, with a distance of 15 metres between each photocell (Mújica et al., 2009).

Agility 10 x 5 metres: The Eurofit test battery was employed, since according to different authors, its dynamics are similar to those of a football match (Kaplan et al., 2009).

Endurance test

The Probst test was carried out (Probst, 1989) to assess the aerobic power of the player and their ability to recover.

The speed at which the test should begin according to Probst is 10.8km/h, and every 2 laps of the circuit (that is, in each stage), the running speed was increased by 0.6km/h, with it being necessary to maintain the running speed at each level. The speed increased until the player could no longer maintain the speed set. Between each level there was a rest period of 30 seconds, with this parameter being that which differentiates this test from others that also assess aerobic endurance in athletes, but continuously: Bangsbo, 1998, Cazorla and Farhy, 1998, Conconi, 1982, Léger, 1988, amongst others.

The test was repeated just once using Suunto heart rate monitors, noting the last period completed in order to subsequently calculate the metres covered.

Statistical analysis

The normality of the sample was confirmed by the Kruskall-Wallis test. The descriptive data of the basic characteristics were recorded as well as the functional tests by the age category to which the players belonged, showing the mean and standard deviation of the same and the differences between each of the variables in accordance with the categories of the players by One-way ANOVA, with a significance of $P<.05$ being considered. The differences were established between the categories by Post hoc analysis with Tukey's test. Likewise, the correlations were determined by Pearson's test between the different study parameters. The SPSS 15.0 for Windows Statistical Software (SPSS, Chicago, Ill) was used.

RESULTS

Table II displays the results for jumping, speed, agility and endurance. We can see that significant differences appear in all the tests in accordance with the category, except in the endurance test, in which U19 players showed higher values than semi-professionals. Between the U14s and U16s significant differences were noted in speed tests of a distance of 30 metres (0-30 and 10-30m). In the U16 and U19 categories, the differences are found mainly in the jumping and acceleration tests (0-5m with and without reaction). Likewise, no significant differences were found for categories between U19s and semi-professionals, except in the 5-10 metre speed test. We observed how the maximum heart rate dropped as the category of player increased.

Table II. Functional variables of the different categories

	U14s (N=20)	**U16s** (N=37)	**U19s** (N=40)	**Semi-professional** (N=19)	*** One-way ANOVA**
Jumps					
SJ (cm)	33.67±4.47 c,d	34.84±4.25 c,d	38.63±3.31 a,b	39.63±4.17 a,b	0.000
CMJ (cm)	37.10±4.50 c,d	37.11±4.90 c,d	42.48±4.13 a,b	42.65±4.09 a,b	0.000
Speed					
React. 5m (sec.)	1.757±0.05 c,d	1.732±0.07 c,d	1.615±0.06 a,b	1.612±0.06 a,b	0.000
0-5m (sec.)	1.004±0.05 c,d	0.984±0.50 c,d	0.939±0.05 a,b	0.932±0.04 a,b	0.000
5-10m (sec.)	0.751±0.04 D	0.728±0.04	0.750±0.04 D	0.708±0.08 a,c	0.008
0-10m (sec.)	1.760±0.08 c,d	1.716±0.08	1.689±0.07 A	1.660±0.09 A	0.001
10-30m (sec.)	2.648±0.12 b,c,d	2.516±0.23 a	2.470±0.08 a	2.417±0.05 A	0.000
0-30m (sec.)	4.454±0.36 b,c,d	4.285 ±0.21 a	4.191±0.12 a	4.134±0.11 A	0.000
Agility					
Foot-ag-15m (sec.)	3.509±0.15 b,c,d	3.354±0.15 a,c,d	3.227±0.18 a,b	3.212±0.20 a,b	0.000
Ag-10x5m (sec.)	18.652±0.62 b,c,d	17.991± 0.79 a,d	17.725±0.80 a	17.303±0.56 a,b	0.000
Endurance					
Probst (metres run)	2214.08±343.5 6 c,d	2497.88± 392.84	2725.24± 457.24 a	2660.0± 347.48 a	0.001
Maximum heart rate (beat/min.)	199.00±6.10 D	198.18± 6.55 d	194.55±8.06	191.41±7.53 a,b	0.011

React. 5m = Reaction 5 metres, Foot-ag-15m = Football agility 15 metres, Ag-10x5m = Agility 10 x 5 metres.
Tukey Post hoc test:
a: Difference with respect to U14s.
b: Difference with respect to U16s.
c: Difference with respect to U19s.
d: Difference with respect to semi-professionals.

There are significant differences in all the tests in accordance with category, except in the endurance test, where U19 players had higher values than semi-professionals. There are differences between the U14 and U16 categories, in which there are significant differences between the speed tests over distances of 30 metres (0-30 and 10-30). Between the U16 and U19 categories, the differences were found mainly in the jumping and acceleration tests (0-5m with and without reaction). Likewise, there were no significant differences between

U19s and semi-professionals, except in the 5-10 metre speed test. We observed how the maximum heart rate decreased as the category of players increased.

Table III. Correlations of the functional parameters of the total sample

Significant correlations were established in many variables, although we can observe how Probst's test displays the lowest significance values. Figures 1 and 2 detail the main correlations between the jumping and acceleration tests between 0 and 5 metres without reaction and the total time over the 30 metres.

		React . 5m	0-5m	5-10m	0-10m	10-30m	0-30m	Foot-ag 15m	Foot-ag 15m	SJ	CMJ
0-5m	Pearson's r	.511(**)									
	Significance	.000									
5-10m	Pearson's r	.140	.344(**)								
	Significance	.175	.000								
0-10m	Pearson's r	.371(**)	.805(**)	.793(**)							
	Significance	.000	.000	.000							
10-30m	Pearson's r	.337(**)	.476(**)	.444(**)	.566(**)						
	Significance	.001	.000	.000	.000						
0-30m	Pearson's r	.352(**)	.670(**)	.500(**)	.719(**)	.541(**)					
	Significance	.000	.000	.000	.000	.000					
Foot-ag-15m	Pearson's r	.505(**)	.380(**)	.151	.339(**)	.273(**)	.323(**)				
	Significance	.000	.000	.148	.001	.008	.002				
Ag 10x5	Pearson's r	.385(**)	.287(**)	.196(*)	.330(**)	.261(**)	.371(**)	.531(**)			
	Significance	.000	.002	.036	.000	.005	.000	.000			
SJ	Pearson's r	-.463(**)	-.506(**)	-.361(**)	-.527(**)	-.617(**)	-.496(**)	-.297(**)	-.287(**)		
	Significance	.000	.000	.000	.000	.000	.000	.004	.002		
CMJ	Pearson's r	-.558(**)	-.551(**)	-.342(**)	-.557(**)	-.634(**)	-.508(**)	-.365(**)	-.333(**)	.885(**)	
	Significance	.000	.000	.000	.000	.000	.000	.000	.000	.000	
Probst	Pearson's r	-.333(**)	-.310(**)	-.082	-.235(*)	-.347(**)	-.263(*)	-.302(**)	-.400(**)	.198	.160
	Significance	.002	.003	.435	.024	.001	.011	.009	.000	.058	.127

** The correlation is significant at level 0.01 (bilateral).
* The correlation is significant at level 0.05 (bilateral).

Figures 2 and 3 below are graphs displaying correlations between the two jumping tests and the 0-5m speed tests without reaction and the 0-30m test without reaction, since they show a rather notable significance.

Figure 2. Correlations between the jumping and acceleration tests over 0-5m without reaction in all categories (n=118)

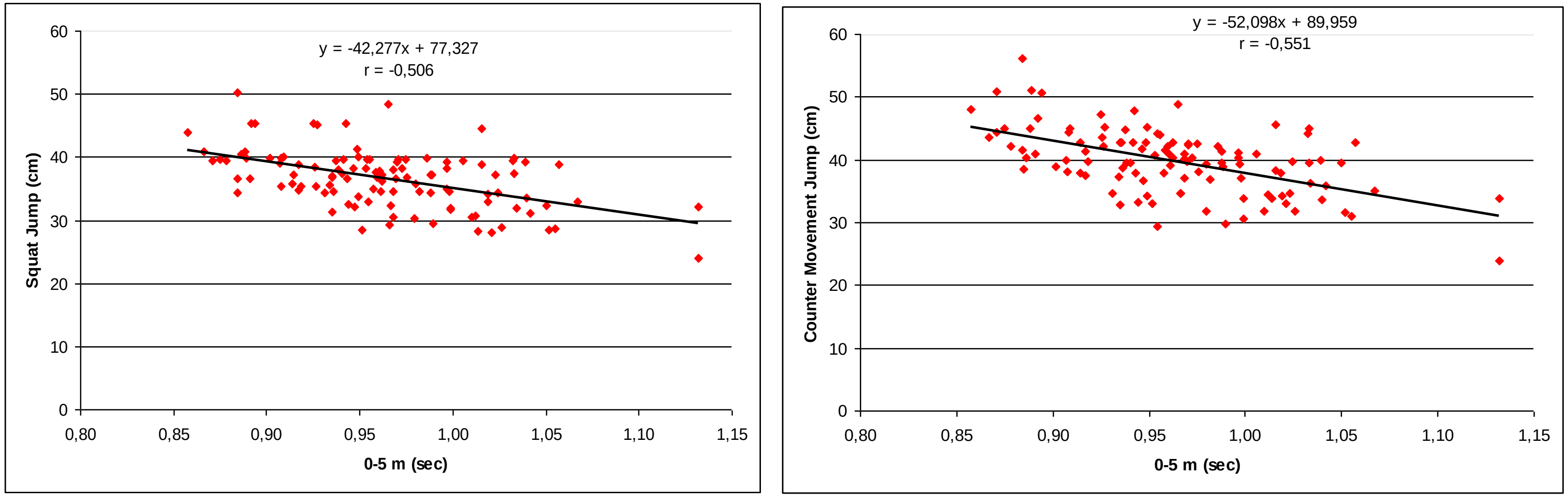
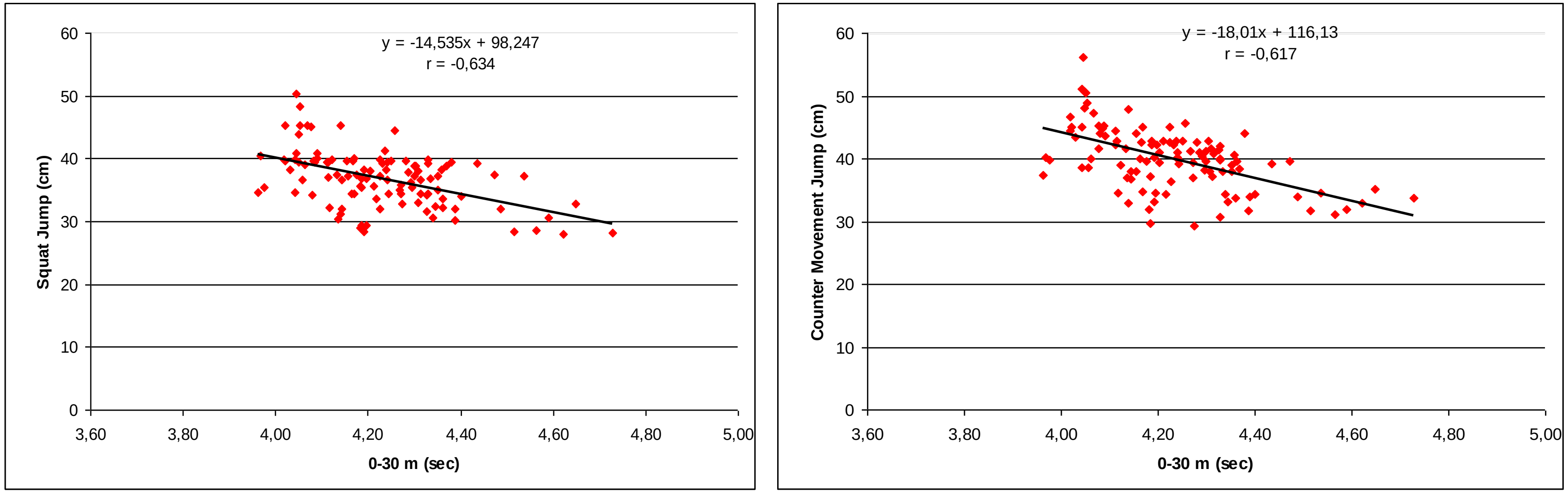


Figure 3. Correlations between the jumping and acceleration tests over 0-30m without reaction (n=118)



DISCUSSION

In this study, four categories of youth football were analysed. Our main finding was that there was an increase in the values of the different tests for physical condition, speed, agility and endurance as the age of the subjects increased. Nevertheless, no significant changes were detected between close age categories, with there being in the tests of explosive strength, acceleration and agility over 15 metres, a better differentiation from the U19 category upwards; that is from 17 years of age with respect to the younger categories, while in the speed and endurance tests, significant differences were found between the categories of under 14s and the rest of the categories, that is players over 15 years of age.

It is during the latter stages of puberty that muscular strength and power display the greatest increases in male teenagers. This peak in the increase in strength occurs after the peak in the increase in height (Beunen and Malina, 1988, Beunen et al., 1988, Malina et al., 2004a). The highest percentage of change in physical performance, as well as in body growth in general occurs at 14 and 15 years of age (Malina et al., 2004b).

In the speed tests, this increase slows down earlier in time. Papaiakovou et al., (2009) found a plateau in performance in the speed test over 30 metres in boys at 15 years of age, both in acceleration over 10 metres and in speed over 30 metres and from 10 to 30 metres.

The players displayed a significant increase of height in the jumping test with age and we found a significant difference both in SJ and in CMJ between the two youngest categories (U14s and U16s) and the two oldest (U19 and semi-professional). This increase in explosive strength in jumping is corroborated in different articles on teenagers. Both in football players, (Le gall et al., 2010, Nedeljkovic et al., 2007, Vaeyens et al., 2006), and in boys who do not practice sport (Castro et al., 2009, Ortega et al., 2011). Nedeljkovic et al., (2007), found significant differences in the vertical jump (CMJ), with players being classified by age categories from U12s to U17s, between all groups except those of 12-13 and 15-16. Le Gall et al., (2010) found an increase in the vertical jump levels (CMJ with arm movement) in U14s, U15s and U16s, in accordance with their age and position, but did not find significant differences with regard to their subsequent level of performance after they graduated from the Clairefontaine National Football Institute.

Likewise, as with our study, there is evidence that significant differences are not usually found when age groups that are very close to each other are compared (Gil et al., 2007, Malina et al., 2004b). Although increases were found in SJ and CMJ in the teams of 14, 15, 16 and 17 years of age, in Spanish footballers these were not significant. As has been confirmed both in previous studies and in ours, it is possible that the lack of a significant difference between close age groups is due to the number of subjects studied not being large enough to make the existing differences significant.

In our sample, all the measurements of speed improve significantly with age. However, the differences are not significant in all categories or all measurements. As with the strength tests, the main significant differences were found between the U14 and U16 categories and the U19 and semi-professional categories in the measurements of reaction-5m, 0-5m and 0-10m. All of the above are measurements on which acceleration has an influence, while in the measurements between 5-10 and 0-30m, the significant differences were found between the U14 category and the rest, with a plateau in performance in these tests from 15 years of age, as found by Papaiakovou et al., (2009). This can be explained since the 5-10m and 0-30m tests depend more on speed than acceleration, the latter being more important in the reaction-5m, 0-5 and 0-10m, in which the gain of strength has more importance and it occurs until the later stages of adolescence (Malina et al., 2004a).

The increase in speed with age has been confirmed by various studies in young football players (Le Gall et al., 2010, Malina et al., 2003). Papaiakovou et al., (2009) analysed the change in speed over 0-30m with measurements being taken every 10 metres in boys who are not enrolled in exercise programmes outside of school. They found differences between age groups, especially when they were compared with those of 2 or more years older but not between a year and consecutive age groups. They therefore found similar results to those of our study, in which there were no significant differences between close age groups. Furthermore, in line with these findings, Castro-Piñero et al., (2010) found an increase with age of speed over 30-m in non-footballer Spanish children of 6 to 17 years of age.

In the agility tests, performance increased with age. In the 15 metre test, dependent on the phosphagen system, the U14 and U16 groups showed differences with the other groups. However, the 10 x 5m exercise, more conditioned by the anaerobic factor, found differences between the U14 group and the rest, and between the U16 group and the semi-professionals, without any significant differences being noted between the other groups. A similar dynamic was observed between the 15m test and the speed tests, with a plateau in performance from 15 years of age and in the 10 x 5m test, a significant improvement until the oldest age group. This may be due to the changes of direction that these tests require being influenced by strength level, which as we have seen continue developing until the later stages of puberty (Malina et al., 2004a).

We have not found studies that analyse the differences by age groups in agility tests over 15m. However, in the 10 x 5m test Nedeljkovic et al., (2007) found significant differences, classifying players by age groups (U12 to U17). Ortega et al., (2008) analysed the results of the 4 x 10m test in Spanish teenagers, finding differences for teenagers aged 13 to 17 years old, since although they analysed a large amount of tests with the Eurofit test battery, they changed this test for the 10 x 5m test. Likewise, Ortega et al., (2010) found an improvement in European teenagers of 13 to 17 years of age.

García et al., (2004), state that the Probst test used in this study seems to be an excellent medium, not only for analysing parameters such as race distances and heart rate, but also for determining the anaerobic threshold in footballers at any stage of their careers. The distance run in the Probst test increased with age except in the semi-professional team. Significant differences were found between the U14 group and the U19 and semi-professional groups. Nevertheless, we did not find articles in literature that assess the change in endurance with age using the Probst test.

Different studies found increased endurance measured by various tests. Vaeyens et al., (2006) found an increase with the age of players in U13 to U16 categories and Gil et al., (2007) in players of 14 to 17 years of age. Malina et al., (2004a) found an increase in development in players of 13 to 15 years of age.

The explanation was that aerobic development increases with maturity and pubertal development (Shephard, 1999). Meckel et al., (2009) state that the gradual increase experienced in the endurance parameter is closely related to the progressive anatomical physiological development experienced by the body of a young footballer, with the subsequent and logical functional improvement, which demonstrates that the aerobic system plays an important role in maintaining the level of intensity during a football match in players of these ages.

Correlations were found between the different speed, agility and jumping tests and to a lesser extent, the endurance test, although the correlations between this test and speed and agility should be noted.

The explosive strength tests are strongly correlated with the tests of speed and agility, particularly with shorter tests. This coincides with the results obtained in different studies (Chamari et al., 2004, Chelly et al., 2010). Likewise, a correlation is also found between the tests of explosive strength and speed over greater distances, which coincides with Smirniotou et al., (2008), who found that SJ and CMJ are highly correlated with speed in 10 and 30 metres in young sprinters.

Likewise, the agility tests were correlated with the tests of explosive strength and speed, as they were in the studies by Meylan et al., (2009), which found a correlation between the agility test over 10 metres with changes in direction and the CMJ in 13 year old footballers. Little et al., (2005) found a relationship between the zig-zag 20m agility test and acceleration over 10 metres and the maximum speed over 20 metres in players of the English first and second divisions.

CONCLUSION

We observed how an improvement in performance with age was obtained in the speed, agility, explosive strength and endurance tests, although significant differences in close age groups are not usually observed. Thus, a plateau occurs in performance in explosive strength and acceleration from 17 years of age and in speed and agility from 15 years of age.

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