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The adolescent basketball player: the importance of some anthropometric characteristics for speed, resistance, power and agility.

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KEYWORDS

basketball, adolescents, anthropometry, athletic tests.

ABSTRACT

Given the paucity of data in relevant literature on the relationships existing between anthropometry and performance in adolescent basketball players (BP), we investigated on 64 adolescent BP aged 13/17 years old belonging to two provincial and élite Italian teams. They were subdivided into under-14 (U-14) and under-17 (U-17) subjects. Body composition and somatotypes were ascertained, together with speed, resistance, power and agility tests. In both U-14 élite and province sub-groups differences emerged for most of the parameters considered, while the U-17 sub-groups did not display a similar neat differentiation. Age appeared to be positively correlated with the athletic tests; stature positively correlated with VO_2 max and speed tests but negatively with agility, while weight appeared not to influence the tests. Skinfolds resulted to be negatively correlated with VO_2 max and jumps, but positively with speed and agility. Fat mass resulted to be positively correlated with speed and agility and negatively with jumps. Body density appeared to be positively correlated with jumps and resistance and negatively with VO_2 max, speed and agility. As the latter aspect (together with strength and power) appears to be an important predictor for success in BP performance, the present small investigation should be improved and more accurately verified.

Introduction

Basketball is a very popular sporting activity requiring a variety of movements. During this physiologically intermittent sporting activity in fact, athletes must cover 4500 meters and must run, dribble, jump and perform stuffing of position (McInnes, Carlson & McKenna, 1995). To reach excellent performance this endurance game requires physical characteristics often highlighted in relevant literature, which reports a number of anthropometric variables associated to endurance performance. They range, in fact, from height, weight, BMI, fat, total skinfolds, but also thickness of lower limbs, length of the upper legs, thigh girth and length of the limbs (Koley, Singh & Satinder, 2011; Visnapuu & Jürimäe T., 2008). The optimal combination of characteristics needed to reach success (i.e.: body size, physique, technical skills and motor abilities) are difficult to be assessed in young athletes (Vaeyens et al., 2008). They are a source of investigations whose approaches are often multivariate (Guimarães et al., 2019). The anthropometric approach is usually focused not only on bodily measures (height, sitting height, weight, arm span, upper and lower limbs lengths), but also on somatotype and body composition assessments (Coelo et al., 2010). Usually, in fact, young BP are taller and heavier than their peers and show a high degree of fat-free mass and show greater hands then their equal in age subjects (Hoare, 2000; Torres-Unda et al., 2013). During adolescence

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biological maturation is highly variable and this appears to affect the training experience, as shown by te Wierike et al. (2015) and Ramos et al. (2018). However, as shown by Beunen & Malina (2008), anthropometrical and physiological differences tend to disappear during growth, therefore technical skills appear to be important for selection in order to correctly identify the position in a team (te Wierike et al., 2015; Karalejič, Jakoviljevič & Macura, 2011). Other components are important, as they are connected to somatotype, physique and general aspect. Just to mention two of them, interesting are old data from two cohorts of BP aged from 13.1 to 13.6 years old subdivided into amateurs and "professionals", who showed a greater maturity level than the same-age control group (mainly due to selection which requires higher stature and early maturers - Viviani, Lavazza & Grassivaro Gallo, 1994). The "professional" sub-group, more prone to the pressures and expectancies of their professional environment and those of the opponent teams, desired a wider body than the control group and their amateur colleagues. The latter, because of their lower level, probably did not match their strength against the tall and stout opponents in the rival teams, so they did not desire a wider body. In another study (Viviani et al., 1991) was found that BP males have a greater self-evaluation of their motor competence than BP females, that their motor self-efficacy is highly correlated to self-concept and that the excess of weight negatively influence personal self-evaluation. The aim of the present survey was mainly descriptive and comparative. We in fact collected data from 4 male basketball teams (under 14 years old – U-14 and under 17 y.o – U-17) participating in two different categories (élite and province). We evaluated their body composition, somatotype, and some physical tests connected to speed, resistance, power and agility. This in order to gain insights useful to better direct these young athletes in their sporting practice (choice of roles, physical characteristics to be achieved, types of training to be proposed and so on).

Materials and methods

Subjects were 64 boys aged 13-17 belonging to 4 different teams. 18 of them belonged to an *èlite* team (average age in months=164.9±3.7), 16 to a province team (aged 163.1±5.5 months); 13 of them to an *èlite* team (age=199.2±3,3) and 17 to a province team (age=187.8±9,9). All anthropometric measurements were taken according to the protocols of the Working Group on Kinanthropometry (Ross & Marfell-Jones, 1995) and Lohmann, Roche & Martorell's Instructions (1992). The anthropometric equipment included height and weight scales, a small sliding caliper, a flexible steel tape measure and an Holtain caliper (Holtain Ltd., Crymych, UK). Somatotypes were collected using Carter & Heath's instructions adjusted for children (1990, pages: 367-384). The Body Mass Index BMI (weight/stature^2) and the Height-Weight Ratio HWR (stature/cubic root of weight) were calculated. Body composition was estimated, to calculate body density, using the sum of triceps, subscapular and abdominal skinfolds. Then we estimated the percentage of body fat (FAT%), the Fat Mass (FM) and the Fat Free Mass (FFM) of our athletes (Brozek et al, 1973; Lohman, 1980). As the use of these generalized equations could over- or underestimate the percentage of body fat (because the skinfold equations vary with maturation level), we used the 13-17 years old male population-specific model conversion proposed by Heyward & Wagner (2004). Then, as according to Drinkwater, Pyne and McKenna (2008), that recommend a careful selection of tests for BP to ascertain resistance, we utilized the Léger's test (Multistage 20-m. shuttle-run test for aerobic fitness, 1988), which permits to ascertain the maximal consumption of oxygen (ml/kg/min) (Léger & Lambert, 1982, Fig. 1).

As recently shown in Mayorga-Vega, Aguilar-Soto & Viciana's meta-analysis (2015), even if the validity (criterion-related) of the Leger's protocol is statistically higher for adults, it is not bad for children as r_p = 0.78 (0.72-0.85). For the assessment of leg muscular mechanics and power, we used the Bosco's test with Erdo tester connected, to measure the time of the jump (Bosco & Viitsalo, 1982; Bosco, 1992). As Mancha-Triguero et al.'s (2019) systematic review showed that speed and agility are the less studied qualities in BP, we decided to investigate these two aspects. For speed, that recently Ramos et al. (2020) showed to be important for BP male adolescents, the subjects were tested on three different length tests: 9 meters, 18 meters - change of direction – 9 meters. The agility test was administered many times, in order to gain a reliable average score. Fig. 2 shows how it has been performed.

We used standard descriptive statistics for measures and derived variables. A two-ways ANOVA was carried out to compare the subgroups. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. The Statistical Package for Social Science, version 17.0, was used to analyse data.

Results

The main results found for the 4 sub-groups are shown in table 1.

U-14 élite	N	Mean	SD	Min	Max
Age (months)	18	164,96	3,69	158,90	170,50
Weight (kg)	18	54,99	8,64	40,00	70,50
Height (cm)	18	165,97	9,52	154,50	182,00
Chest circumference	18	80,82	5,41	71,20	90,00
Upper arm girth	18	23,82	2,04	19,20	26,60
Calf circumference	18	33,88	2,25	29,50	36,90
Biepicondylar breadth of the femur	18	7,90	0,65	6,10	8,90
Biepicondylar breadth of the humerus	18	6,50	0,89	5,30	9,60
Triceps skinfold	18	10,83	3,71	6,40	20,40
Subscapulr skinfold	18	7,60	2,78	5,20	14,20
Supraspinale skinfold	18	12,94	4,26	7,00	21,00
Abdominal skinfold	18	12,70	4,92	6,20	27,60
BMI	18	19,86	1,70	16.44	22,52
HWR	18	43,77	1,35	41,46	45,82
Endomorphism	18	3,18	0,88	1,89	5,52
Mesomorphism	18	2,81	1,24	0,49	6,14
Ectomorphism	18	3,45	0,99	1,77	4,96
% Fat	18	11,80	3,03	7,75	20,98
Fat mass	18	6,58	2,20	3,62	11,39
Fat free mass	18	48,41	7,18	35,68	61,73
VO_2 Max	18	44,43	3,07	40,25	49,00
U-14 province	N	Mean	SD	Min	Max
Age (months)	16	163,09	5,52	149,70	170,30
Weight (kg)	16	63,52	12,74	42,60	87,70
Height (cm)	16	168,04	9,05	153,30	186,50
Chest circumference	16	85,70	6,81	71,20	99,50
Upper arm girth	16	27,08	3,64	20,80	33,10
Calf circumference	16	36,16	2,99	31,20	42,20
Biepicondylar breadth of the femur	16	8,13	0,82	6,20	9,20

Biepicondylar breadth of the humerus	16	6,49	0,35	5,90	7,10
Triceps skinfold	16	16,55	6,90	5,80	29,60
Subscapulr skinfold	16	10,95	5,60	4,40	20,80
Supraspinale skinfold	16	19,26	8,17	6,80	30,40
Abdominal skinfold	16	15,54	4,58	8,60	22,00
BMI	16	22,43	3,76	16,18	29,00
HWR	16	42,38	2,47	38,43	48,12
Endomorphism	16	4,38	1,54	1,57	6,44
Mesomorphism	16	3,54	1,61	0,01	5,79
Ectomorphism	16	2,54	1,66	0,16	6,64
%FAT	16	15,37	4,67	8,61	23,91
Fat Mass	16	10,23	5,01	4,01	20,97
Fat free Mass	16	53,28	8,20	38,59	69,63
VO_2 Max	16	40,03	2,63	36,75	43,75
U-17 élite	N	Mean	SD	Min	Max
Age (months)	13	199,19	3,33	195,00	206,10
Weight (kg)	13	72,45	9,85	57,00	95,30
Height (cm)	13	182,77	4,71	173,00	189,00
Chest circumference	13	90,61	5,26	80,50	100,80
Upper arm girth	13	27,28	2,77	21,90	32,20
Calf circumference	13	37,15	2,78	32,70	42,30
Biepicondylar breadth of the femur	13	8,51	0,23	8,00	8,70
Biepicondylar breadth of the humerus	13	7,04	0,38	6,50	7,80
Triceps skinfold	13	11,37	4,41	5,60	21,20
Subscapulr skinfold	13	9,15	3,23	5,20	15,40
Supraspinale skinfold	13	16,52	8,90	7,20	36,40
Abdominal skinfold	13	14,26	6,59	8,00	28,20
BMI	13	21,69	2,77	16,84	26,68
HWR	13	43,99	2,00	41,32	47,81
Endomorphism	13	3,34	1,34	1,67	5,88
Mesomorphism	13	2,60	1,29	0,34	4,56
Ectomorphism	13	3,62	1,47	1,67	6,42
%FAT	13	12,90	4,03	8,43	21,86
Fat Mass	13	9,66	4,41	4,98	20,83
Fat free Mass	13	62,79	6,00	52,02	74,47
VO_2 Max	13	49,00	3,28	43,75	54,25

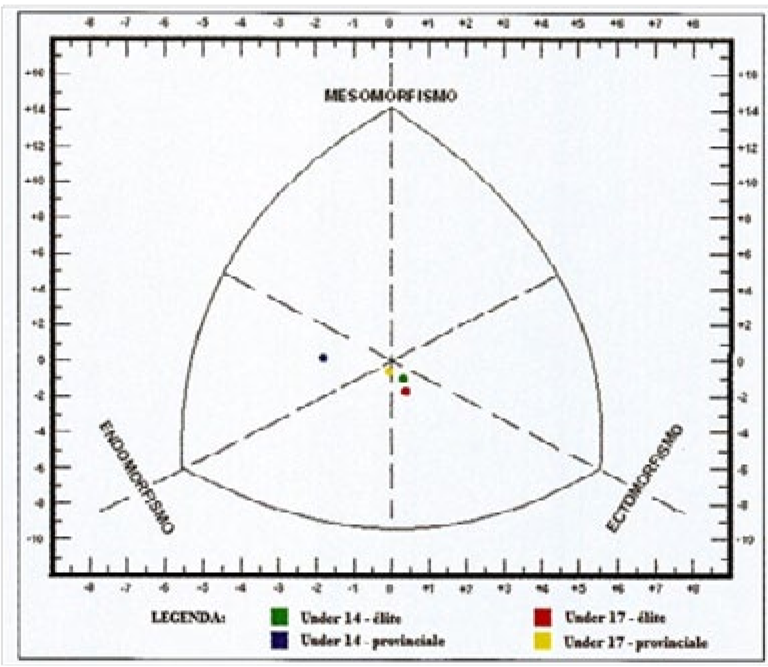
U-17 province	N	Mean	SD	Min	Max
Age (months)	17	187,84	9,94	171,60	202,10
Weight (kg)	17	65,18	10,35	47,00	89,50
Height (cm)	17	175,14	6,97	166,00	186,00
Chest circumference	17	88,84	6,91	76,80	107,00
Upper arm girth	17	26,81	3,23	22,00	36,30

Calf circumference	17	36,95	3,23	31,80	43,80
Biepicondylar breadth of the femur	17	8,25	0,50	7,30	8,80
Biepicondylar breadth of the humerus	17	6,71	0,42	6,10	7,40
Triceps skinfold	17	11,29	4,61	5,60	22,60
Subscapulr skinfold	17	9,49	3,33	5,80	17,80
Supraspinale skinfold	17	15,79	6,02	8,00	30,60
Abdominal skinfold	17	14,02	4,98	7,80	27,60
BMI	17	21,21	2,84	16,85	25,87
HWR	17	43,70	2,00	40,78	46,92
Endomorphism	17	3,49	1,08	1,81	5,84
Mesomorphism	17	3,05	1,22	0,79	5,22
Ectomorphism	17	3,41	1,47	1,27	5,76
%FAT	17	12,91	3,54	8,55	22,80
Fat Mass	17	8,72	3,87	4,02	20,41
Fat free Mass	17	56,46	6,91	42,98	69,09
VO_2 Max	17	44,57	2,97	38,50	52,50

Table 1 – Main characteristics of the four sub-groups of BP.

In the U-14 sub-groups, between the two categories of athletes (*élite* and province), differences emerged for all the parameters analysed (in general: $p<.05$), apart stature and FFM. Greater differences ($p<.01$) were found for most of the skinfolds, the somatotype components and agility, jumps, VO_2 max and fat mass. The two U-17 sub-groups showed a neat difference from the previous age group, as significant differences emerged only for: stature ($p<.05$), VO_2 max ($p<.01$), agility ($p<.01$) and FFM ($p<.05$). Regarding the somatotypes, the under 14 (province sub-group) tended towards an endomorph-mesomorphic physique, the under 17 (province subgroup) resulted to be central, while the two *èlite* subgroups tended to be ectomoph-mesomorphs.

Fig. 3 depicts the somato-chart showing the average somatotypes of the four sub-groups. (Somatochart of four sub-groups of Italian adolescent BP).



We found a positive correlation between age and athletic tests (r was always higher than .05 for VO_2 max and jumps - p<.01). Stature appears positively correlated with VO_2 max (r=.36, p<.01); speed tests (r=.25, p<.05) and negatively correlated with agility (r=-.39, p<.01). Weight does not appear to influence the athletic tests. Circumferences and body diameters did not show significant correlations, while the four skinfolds highlighted negative correlations with VO_2 max and jumps (p<.01), and positive correlations for speed and agility (p<.01). Regarding body density, a positive correlation was found for jumps and resistance (p<.01), conversely, for speed and agility, the correlation resulted to be negative (p<.01). Fat mass resulted to be significantly and negatively correlated with jumps (p<.01), while for speed and agility it showed to be positively correlated (p<.01). This happened also with the Léger's test (p<.05).

Discussion

Basketball is a very dynamic sporting activity as, in a nutshell, it requires to move at high speed while changing directions. The game demands during all the context require a certain level of endurance, therefore, a moderately body composition should be maintained while strength, power and agility mut be improved to reach success, depending on the position in the team, even if the latter has not the same importance found in other sports like football (Ransone, 2017). If a lower height, body mass and body Fat% is usually requested for guards (Sallet et al., 2005), forwards and centers show high stature and weight, and higher values of body fat. In this context good predictors of BP performance are power, strength and agility: in fact, successful athletes show higher sprint times and agility (Delextrat & Cohen, 2008). In effect, the training programmes include not only work to improve the cardiovascular base, useful to aerobic fitness, but are mainly focused on strength, agility and power development (Meckel, Gottlieb & Eliakim, 2009). Among the many characteristics that a coach is request to supervise for a balanced development of very young players (technical, tactical, motor, physiological and psychological) in the context of the individual growth, maturation, general development and the somatic build, correct anthropometric diagnoses are considered to be fundamental by many Authors (Dežman, Trninić & Dizdar, 2001; Ostojic, Mazic & Dikic, 2006; Sampaio et al., 2006; Montgomery et al., 2008; Vaquera et al., 2015). In our U-14 sub-samples, in effect, significant differences were not found only for height and FFM. These differences are mostly due to the presence, un the élite sub-group, of a coach who permits different performances during a championship. Both sub-groups of athletes were taller and heavier than the majority of the same age Italian adolescents (Cacciari et al., 2002), and the peripubertal soccer players athletes studied long time ago by Viviani, Casagrande & Toniutto (1993). Data are also congruent with those found decades ago by Viviani & Casagrande (1990) and Viviani et al. (1991). Analogous results were found for the U-17 sub-samples, indicating the fundamental role of selection (or even self-selection, for the U-14 boys). In the two U-17 sub-samples the small differences found, however, may be inconsistent with the great discrepancy present in competitive performances requested during a league, so it is possible, for this age group, that other factors such as technique, tactics and psychology play a role. For BMI and HWR comparisons were not possible due to the lack of existing Italian data. For example, a group of more than 1100 mixed Sicilian adolescents aged 13±3.1 years old, in which half of the participants were overweight or obese, showed a BMI, on average, of 21.8±3.1, quite congruent with our data (Grosso et al., 2013). For somatotype, comparisons with older data found in Italian adolescent students (n=40: 3.0-3.0-3.2; Viviani et al., 1991), revealed the tendency towards the central somatotype. Children aged 11/12 years old showed this tendency as well (3.1-3.1-3.1), not differently from a 13/15 cohort (2.9-2.9-3.3) reported by Viviani et al. (1996). Adult Italian subjects practicing moderate levels of physical training, however, revealed to be mesomorph-endomorph (n=62: 3.4-3.4-2.8; Viviani & Zanuso, 1993). Our U-17 province team (3.5-3.1-3.4) tended towards these scores more than the élite one (3.3-2.6-3.6). In another study (Viviani & Grassivaro Gallo, 1997), tennis players aged 13.5 years old (n=30: 3.5-4.1-3.5) and a group of the same age swimmers (n=30: 1.9-4.2-3.8) tended to be, respectively, mesomorphs and ectomorphic mesomorphs. Soccer players aged 13.1±0.5 years tended to be balanced mesomorphs (1.9-4.4-3.2 - Viviani, Casagrande & Toniutto, 1993). A very small sample of national level Italian BP (Viviani & Casagrande, 1990), aged 17 years old (n=11) showed the following scores: 2.4-3.3-3.3. With a stature of 188.5±6.5 and a weight of 81.7± 9.0 Kg., they were definitely taller and stouter than the present U-17 élite cohort. International relevant literature reports a huge, contrasting and confounding variety of data for young BP. Just to mention some of them, Canli (2017) found a 4.6-4.6.2.2 somatotype in Turkish boys aged 12-14 years old; Zorba et al. (1996) a 1.7-5.2-3.4; while Gryko et al (2018) reported an average 2.1-3.8-4.2 for a sample of 14.9 years old compatriots. Ayan & Erol (2016) found an ectomorphic-mesomorphy profile in the male U-15 Turkish National Team (3.0-4-0-3.6). Marta et al. (2011) found a 3.6-1.2-1.5 somatotype in Portuguese boys. Mathur et al. (1985) found an average 1.9-5.3-3.4. These unparallel findings could be ascribed to different factors, ranging from age, maturity status, level of performance, just to mention the most important among them. Some Authors claim that the in pre-pubescence the correlations exiting between body type and motor performance are generally low and limited (Marta et al., 2011), while other Authors assert, in their abstract, that "some anthropometric measures might have moderately negative influence on test results in technical skills in 14 years-old players" (Karalejič, Jakoviljevič & Macura, 2011). Therefore, to navigate in this flood of data is extremely frustrating, because of the impossibility of reliable comparisons. We must bear in mind, at this point, that endomorphy, expressing the degree of adiposity development, acts as a limiting factor in body propulsion and lifting tasks and tends to be negatively correlated with performance in many motor tasks (Malina & Bouchard, 1991). Mesomorphy, which expresses the osteo-muscular development, therefore actively acting on strength and motor performance in general, becomes favourable in boys from early adolescence (Malina, Bouchard & Bar-Or, 2004). As it is strictly correlated with ectomorphism, the boys with good meso- and ectomorphism components show better results in most of the motor domain tests. The body linearity and muscular hypotonia expressed by the ectomorph component (Dumith et al., 2010), permits a better propulsion and lifting body tasks. More important in BP appears to be body composition and, even if a specific body composition appears not be a fundamental factor in BP to reach success, it determines the players position (Ransone, 2017). This because its strong relationships with aerobic fitness and anaerobic power. However, the paucity of data and the high variation in BP adolescents does not permit valid conclusion in this slippery aspect. As agility (the ability to move quickly and change directions), together with strength and power (that in BP results in a quick combination of speed and strength) appears to be an important predictor for basketball performance (Hofman, 2013), the correlations found in our samples are quite congruent. In our BP, in fact, jumps are negatively correlated with fat mass, speed and agility with body density, while VO2max and jumps with the skinfolds. As age, stature and fat mass increase, they favour VO2max, speed and agility, while the increase of body density, favouring jumps and resistance, negatively influences other aspects, such as speed and agility. Therefore, if basketball demands strength, agility and power development, but also aerobic fitness, coaches should include, in their training programs, also efforts to build a good cardiovascular base.

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Images

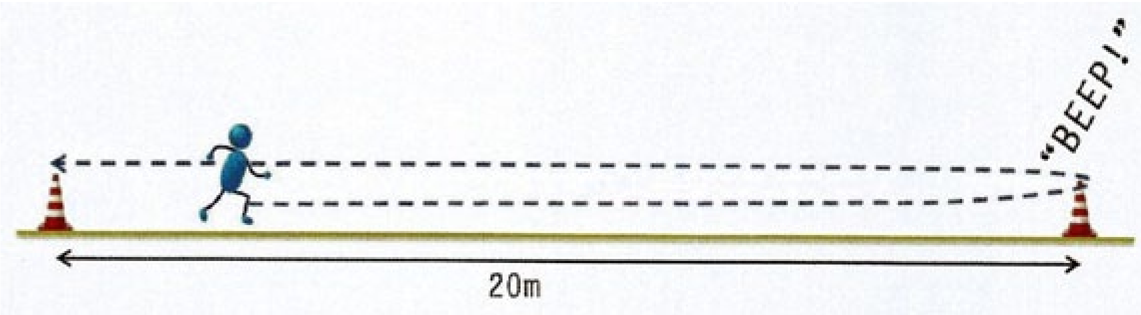

Fig. 1 – In this test subjects must travel a distance of 20 meters within a pre-set time interval. Each athlete must start running and reach the finish point within an audible warning. After that s/he will have to return to the starting point by the next sound. As the test progresses, the time interval decreases, forcing the tested subject to increase her or his speed until s/he can keep in sync with the sound recording.

*VO2 max = 31.025 + 3.238*S – 3.248*A + 0.1536*S*A. Where: S = Final Speed (km·h-1) A = Age (yrs) (S=8 + 0.5 *last stage completed).*

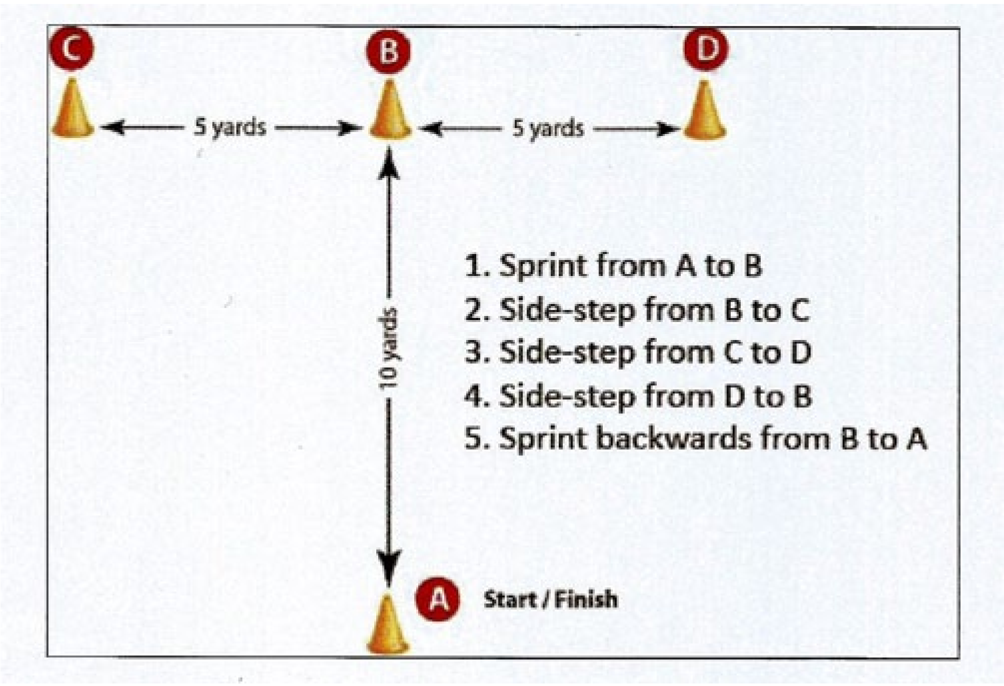

Fig. 2 – The agility test (simplified). The agility test involved a series of athletic movements functional to the game, such as running forward, running backward and sliding sideways. The latter is one of the most used movements by players in the defensive phase. For this reason, it becomes a sort of "focus of attention" during the training sessions.