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Growth, maturation, functional capacities and sport-specific skills in 12-13 year-old- basketball players

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Aim. **The influence of maturity status on body size, functional capacities and basketball-specific skills was evaluated and multivariate relationships between domains of variables were examined in 80 male basketball players 12.0-13.9 years.**
Methods. **Height, body mass and two skinfolds were measured. Stage of pubic hair (PH) was assessed clinically. Functional capacity was assessed with the vertical jump (squat jump, countermovement jump), 2-kg medicine ball throw, hand grip strength, 60-second sit-ups and endurance shuttle run. Performances on four basketball skills were tested: shooting, passing, dribbling and defensive movements. Analysis of covariance with age as the covariate was used to test differences among players by stage of puberty. Associations among body size, adiposity, functional capacities and skills were evaluated with canonical correlation analysis.**
Results. **Maturity status explained a significant portion of variance in body size (F=50.13, P<0.01, η^2=057, for height; F=13.47, P<0.01, η^2=0.26, for weight). The effect of pubertal status was significant for the jumps and upper limb strength, but not for sit-ups or aerobic endurance. Canonical correlations showed an inverse relationship of height and adiposity with skill tests, and a positive relationship between skills and a combination of abdominal muscular strength (sit-ups) and aerobic endurance.**
Conclusion. **Skill appeared to be independent of pubertal status and the tallest group of basketball players did not attain better scores in basketball-specific skill tests.**

KEY WORDS: Athletes - Puberty - Basketball.

Tallness is routinely accepted as essential for success in basketball, although variation in height among players is considerably.[1, 2] Retrospective analyses of medical records of late adolescent, elite French basketball players of both sexes indicated heights that were, on average, two standard deviations above French reference medians long before the start of basketball training;[3, 4] weights of the players were not considered. In an earlier review, mean heights and weights of basketball players 10-18 years of age from several countries ranged between medians and 90th percentiles of United States reference values.[5] Even though size per se is important in youth players, it is confounded in part by inter-individual differences in the timing and tempo of the adolescent growth spurt and sexual maturation.[6] More specifically, some youth may be taller than peers due to early maturation so that the size advantage may be transient and have a differential impact on functional characteristics.

Information on the maturity status of youth basketball players is limited. Among players ≤12 years of age, skeletal and chronological ages tend to be, on average, similar,[7, 8] while in players 13-15 years, skeletal ages tend to be in advance of chronological ages.[7, 9]

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In contrast to maturity status, studies of youth basketball players have generally focused on physique, body composition, and functional and skill characteristics independently of growth and maturation during adolescence. These include descriptions of age-variation in isometric and isokinetic strength;[10, 11] motor coordination;[12] influence of various training protocols;[13] prediction of success;[1] and physiological correlates of a 20-m intermittent recovery test.[14] Most of the samples were late adolescent, primarily 15-16 years of age. Interactions between size and body composition in predicting basketball performance have been considered,[15, 16] but the influence of interindividual differences in biological maturation as a factor affecting functional capacities and sport-specific skills has not been systematically evaluated in young basketball players.

Talent in basketball includes a combination of physical, functional, behavioural and perceptual features and is more complex than indicated by analysis of single items and tests. In this context, the purposes of the present study of youth basketball players are twofold: first, to characterize the growth and maturity status, functional capacities and basketball-specific skills of players 12 and 13 years of age, and second, to evaluate relationships among growth, maturity, functional capacities and skills of the players.

Materials and methods

The sample included 80 youth basketball players 12.0-13.9 years. All were members of eight teams from the Portuguese midlands. The study was approved by the Scientific Committee of the University of Coimbra and by the administrators of each club. Parents of the athletes provided informed consent while athletes gave informed assent.

The number of seasons (expressed as years) of formal participation in basketball was obtained from each player and verified by club records. The federation requires clubs to record the training history of players and data are available on the official web site. The players had 3.9±1.6 years of experience in the sport and trained 3.1±0.4 times per week; sessions ranged from 90 to 120 minutes. At this age, the competitive season extends from mid-September to early-May.

Players from specific clubs visited the laboratory in groups of 8-12 on weekday afternoons. Measurements were taken in the late afternoon. The laboratory was in close proximity of an indoor facility used for the functional and sport-specific tests. Height and weight were measured with a stadiometer (Harpenden model 98.603, Holtain Ltd, Crosswell, UK) and a portable scale (Seca model 770, Hanover, MD, USA) to the nearest 0.1 cm and 0.1 kg, respectively. The triceps and subscapular skinfolds were measured with a Lange (Cambridge, MD, USA) caliper to the nearest 0.5 mm. Skinfolds were summed to provide an estimate of subcutaneous adiposity. Maturity status was assessed as stage of pubic hair (PH) by an experienced physician using the criteria described of Tanner.[17] After the anthropometric and clinical examinations, players moved to the indoor sport facility and performed a 15-minute warm-up largely jogging and stretching.

Five components of functional capacity were measured: 1) *Lower body explosive power and coordination*: squat jump and counter movement jump with the hands at the hips.[18] (Globus Ergo Tester Jump System, Codogné, Italy); 2) *Abdominal muscular strength and endurance:* number of sit-ups completed in 60 seconds; 3) *Upper body explosive power and coordination*: standing 2-kg medicine ball throw; 4) *Static strength*: hand grip dynamometer (Lafayette model, Lafayette, IN, USA); 5) *Aerobic endurance:* 20-meter multistage shuttle-run.[19] Two trials were given for the throw, jumps and hand grip; the better of the two scores was retained for analysis.

Four basketball skills were evaluated.[20, 21] The details of each test are described elsewhere;[22] a short description follows:

Shooting: the player was instructed to shoot, retrieve the ball and dribble to another designated position, and to repeat the process as rapidly as possible for 60 seconds. Two points were awarded for each successful basket, including lay-ups. One point was awarded for an unsuccessful shot that hit the rim from above.

Passing: the test required the player to accurately perform chest pass and retrieve the ball while moving laterally. Each pass hitting the target or the boundary counts 2 points, while those hitting the intervening spaces on the wall counts 1 point.

Dribbling: the player was required to navigate as rapidly as possible a course defined by six cones within a rectangle 5.8 m×3.6 m. The time elapsed to complete the circuit was recorded to 0.01 second using a photocells devices connected to digital timer (Globus Ergo Timer Timing System, Codogné, Italy).

Defensive movements: the player was required to slide laterally without crossing the feet in a sequence of seven changes of direction. Whenever the player changed direction, he was required to touch the floor. The time elapsed to complete the sequence was recorded to 0.01 second using an additional set of photocells connected to a digital timer (Globus Ergo Timer Timing System, Codogné, Italy).

Three trials were given for each test. The first was a practice trial and the sum of the second and third trials was retained for analysis.

With the exception of the 20-meter shuttle run, which was performed at the end of the session, functional and sport-specific skill tests were administered in a 5-station format (shooting plus jumps; passing plus hand grip test; dribbling plus 2-kg ball throw; defensive movement; sit-ups). Groups of 2-3 players were tested with periods of rest at each station [short effort episodes for an average length of 10 minutes] and between stations [about 5 minutes for organization and instruction].

A test-retest protocol separated by one week was undertaken for the functional capacity tests with 21 players. Technical errors of measurement (σ_e) and reliability coefficients (R) were as follows: squat jump: σ_e=1.9 cm, R=0.82; counter movement jump: σ_e=1.7 cm, R=0.88; 2-kg ball throw: σ_e=0.46 m, R=0.92; hand grip dynamometer: σ_e=0.9 kg, R=0.99; 60-second sit-ups: σ_e=3.3 repetitions, R=0.84; aerobic endurance: σ_e=8.3 runs, R=0.86. Within day technical errors of measurement and reliability for basketball skills were as follows: shooting: σ_e=1.6 points, R=0.71; passing: σ_e=3.6 points, R=0.75; dribbling: σ_e=0.35 seconds, R=0.82; defensive movements: σ_e=0.35 seconds, R=0.80.

Statistical anaysis

Descriptive statistics were calculated for two single year age groups for all variables. The distribution of stages of PH was summarized. The potential effect of variation in maturity status in the total sample of players grouped by stage of pubic hair was initially tested with analysis of variance (ANOVA) and then with analysis of covariance (ANCOVA) using decimal age as a covariate for those variables that differed significantly. An alpha level of 0.05 was used.

Canonical correlation analysis was used to examine the relationships between sets of variables. Each of the three domains was collapsed into a canonical variate, which was derived to maximize the linear relationship between domains. The canonical coefficient (r_c) measures the magnitude of the associations and its squared value corresponds to shared variance. The analytical protocol calculated bivariate correlations between each variable and its canonical variate. The coefficients inform the contribution of a single variable to the observed multivariate association. Because it is possible to extract as many pairs of canonical variates as the number of variables in the shortest set of variables in the analysis, only the first canonical variate was reported.

Results

Descriptive statistics of players by age group are given in Table I. Stages of PH ranged from early puberty (PH2) to late puberty (PH4). Most 12-year-old players were in PH3 (46%) while most 13-year-old players were in PH4 (56%). Older players were, on average, 6.4 cm taller (F=10.47, P≤0.05), but the two age groups did not differ in body mass and adiposity. With the exception of abdominal strength and endurance, older players performed significantly better in all functional tests (squate jump, P≤0.05; others, P≤0.01). Players in the two age groups differed in only one skill test; older players performed significantly better in dribbling.

The characteristics of players grouped by stage of PH are summarized in Table II. Players in PH4 were significantly older (P≤0.01) than those in PH2 and PH3. Height and body mass differed significantly among players in the three pubertal groups (Table II left) and differences persisted after controlling for age (Table II right). The gradient in body size was PH4 > PH3 > PH2. A similar influence of pubertal status was apparent in static strength (p≤0.01) and power tasks – jumps and throw (P≤0.01), but not in sit-ups and aerobic endurance run. Results for static strength, squat jump and medicine ball throw persisted when age was statistically controlled. Grip strength and ball throw, both upper body measures, showed the same gradient by pubertal status as height and weight. In the squat jump, players in PH4 performed significantly better than those in PH3 and PH2. In contrast, performances on the four basketball skills tests did not differ significantly among players in the three pubertal groups.

The canonical correlation between morphological indicators and functional capacities was 0.84 (r_c^2=0.70, Eigenvalue = 2.34, Wilks' Lambda = 0.13, F=14.31,

TABLE I.—*Means and standard deviations and absolute frequencies for stages of pubic hair for players in each age group and results of comparisons between groups and estimated effect size (η^2).*

	12.0-12.9 yrs (N=35)		13.0-13.9 yrs (N=45)		F (P)	η^2
	Frequencies	Mean±Sd	Frequencies	Mean±Sd		
Age (years)		12.5±0.3		13.4±0.3		
Sport experience (years)		4.1±1.6		3.7±1.7	1.27 (0.26)	0.02
Stage of pubic hair						
— PH2	8		5			
— PH3	16		15			
— PH4	11		25			
Height (cm)		156.8±8.9		163.2±8.8	10.47 (0.00)**	0.12
Body mass (kg)		50.5±10.8		55.1±14.1	2.51 (0.12)	0.03
Sum of skinfolds (mm)		28.0±15.4		23.9±12.8	1.67 (0.20)	0.02
Squat jump (cm)		24.3±4.7		26.7±4.9	4.90 (0.03)*	0.06
Counter movement jump (cm)		28.3±5.4		31.3±5.1	6.42 (0.01)**	0.08
Sit-ups (#)		39.4±5.7		41.0±7.0	1.32 (0.25)	0.02
Static strength - hand grip (kg)		27.7±4.9		32.6±7.3	11.83 (0.00)**	0.13
2-kg ball throw (cm)		466±84		561±1.26	14.78 (0.00)**	0.16
20-meter shuttle run (m)		934±304		1174±360	9.95 (0.00)**	0.11
Shooting (points)		26.1±7.4		24.5±6.6	1.00 (0.32)	0.01
Passing (points)		83.1±11.3		87.0±10.6	2.53 (0.12)	0.03
Dribbling (s)		18.52±2.18		17.44±1.39	7.17 (0.01)**	0.08
Defensive movement (s)		21.63±1.87		21.19±2.22	0.90 (0.35)	0.01

*P<0.05; **P<0.01.

TABLE II.—*Characteristics of players grouped by stage of pubic hair (PH): means, standard deviations, results of ANOVA and estimated effect sizes comparing pubertal groups (left part of the table); and age-adjusted means, standard errors, results of ANCOVA with chronological age as the covariate for variables differing significantly among pubertal groups (right part of the table).*

	ANOVA					ANCOVA (age as covariate)				
	PH2 (N=13) M±Sd	PH3 (N=31) M±Sd	PH4 (N=36) M±Sd	F (P)	η^2	PH2 (N=13) M±SE	PH3 (N=31) M±SE	PH4 (N=36) M±SE	F (P)	η^2
Chronological age (years)	12.8±0.4	12.9±0.6	13.2±0.2	6.04**	0.14					
Sport experience (years)	4.3±1.3	4.1±1.5	3.6±1.8	1.22	0.03					
Height (cm)	150.5±7.5	155.9±4.6	167.9±7.0	50.13**	0.57	151.1±1.7	156.3±1.1	167.3±1.1	38.61**	0.50
Body mass (kg)	42.6±8.6	49.7±9.3	59.8±13.4	13.47**	0.26	42.9±3.2	49.9±2.1	59.5±2.0	10.79**	0.22
Sum of skinfolds (mm)	26.1±15.5	27.0±14.5	24.4±13.5	0.30	0.01					
Squat jump (cm)	23.8±4.0	24.1±4.7	27.7±4.8	6.39**	0.14	24.1±1.3	24.3±0.8	27.4±0.8	4.14*	0.10
Counter movement jump (cm)	27.2±4.1	28.8±5.6	32.0±5.1	5.27**	0.12	27.7±1.4	29.2±0.9	31.4±0.9	2.67	0.07
Sit-ups (#)	40.1±5.4	39.2±6.4	41.3±6.9	0.89	0.02					
Hand grip strength test (kg)	24.8±5.0	27.9±4.0	34.7±6.8	20.45**	0.35	25.5±1.5	28.3±1.0	34.0±0.9	13.68**	0.27
2-kg ball throw (cm)	429±72	491±0.83	5.76±1.30	10.91**	0.22	442±29	499±19	564±18	6.70**	0.15
20-meter shuttle run (m)	1012±278	1090±372	1070±370	0.22	0.01					
Shooting (Points)	24.5±8.4	24.9±5.9	25.7±7.5	0.19	0.01					
Passing (Points)	83.5±9.1	84.6±9.9	86.5±12.6	0.44	0.01					
Dribbling (s)	18.17±1.81	18.07±1.77	17.69±1.95	0.50	0.01					
Defensive movement (s)	21.31±1.98	21.84±1.90	21.02±2.22	1.30	0.03					

*P<0.05, **P<0.01.

P≤0.01). Correlations between variables and the respective first pair of canonical variates are presented in Table III.

The correlations (Figure 1) suggested that players who were heavier (+0.92) and taller (+0.90) attained better scores in strength and power tasks that did not require displacement of the body through space (hand grip: +0.86; 2-kg ball throw: +0.84). The canonical

TABLE III.—*Correlations among variables and corresponding canonical variates for each combination of two sets of variables and percentages of explained variance plus redundancies extracted by the first canonical correlation between sets of variables.*

	Morphology × Functional capacities	Morphology × Skill	Functional capacities × Skill
Body mass	+0.92	+0.21	
Height	+0.90	–0.44	
Sum of skinfolds	+0.35	–0.91	
Explained variance (%)	59.0	35.3	
Redundancy (%)	41.4	9.8	
Vertical jump	+0.25		+0.45
Situps	–0.00		+0.73
Hand grip	+0.86		+0.32
2-kg ball throw	+0.84		+0.33
Aerobic endurance	–0.26		+0.88
Explained variance (%)	31.7		34.7
Redundancy (%)	22.2		17.1
Shooting		+0.13	+0.39
Passing		–0.10	+0.45
Dribbling (a)		+0.56	+0.91
Defensive movement (a)		+0.66	+0.68
Explained variance (%)		19.1	41.4
Redundancy (%)		5.3	20.5

(a) Signs were reversed because lower scores correspond to better performance.

correlation between morphology and sport-specific skills was 0.53 (r_c^2=0.28, Eigenvalue = 0.38, Wilks' Lambda = 0.69, F=2.46, P≤0.01). The pattern of loadings (Figure 2) suggested that dribbling (+0.66) and defensive movement (+0.56), both time-based skills, were associated with lower levels of adiposity (0.91). The first linear combination obtained to maximize the correlation between basketball skills and functional capacities showed substantial shared variance (r_c=0.70, r_c^2=0.50, Eigenvalue =0.98, Wilks' Lambda =0.39, F=3.89, P≤0.01). Endurance items, 20-meter shuttle run (+0.88) and sit-ups (+0.71), were the primary contributors to performance on the four basketball skills (Figure 3).

Discussion

Body size, adiposity, functional capacities and sport-specific skills of 12-to 13-year-old basketball players were evaluated in the context of variation in pubertal maturation. Height, weight, static strength, upper and lower body muscular and coordination power were significantly influenced by pubertal status. Controlling for chronological age, late pubertal players (PH4) were larger in body size, stronger and more powerful. Canonical analysis indicated overlapping variance between larger body size and strength tests that did not require displacement of the body and were maturity-related. The basketball skills assessed appeared to be independent of pubertal status but were more dependent on morphological (subcutaneous adiposity) and functional (abdominal muscular strength and endurance and aerobic endurance) variables.

The sample of Portuguese youth players had heights that were, on average, above age-specific US reference medians;[23] mean height of 12-year-old players was above the 75th percentile of the reference. Corresponding reference data for the Portuguese population were not available. Compared to Portuguese youth from the Atlantic Islands of Azores [24] and Madeira,[25] the mean heights of 12-and 13-year-old

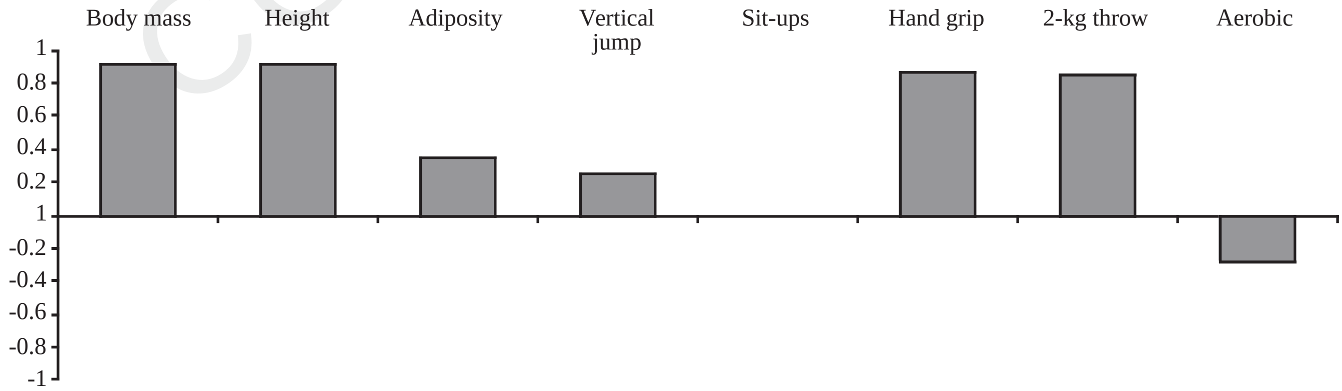

Figure 1.—Correlations of morphological and functional characteristics with their respective first canonical variates.

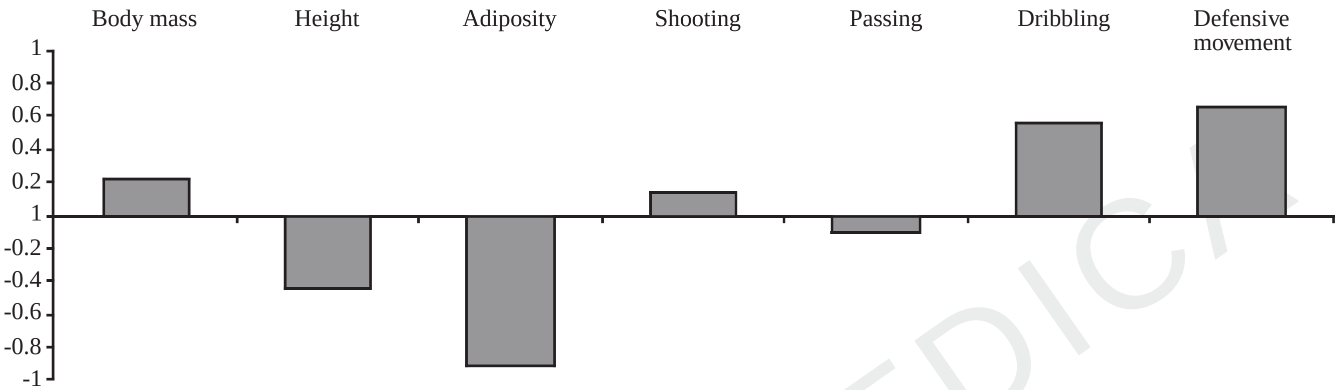

Figure 2.—Correlations of morphological and skill characteristics with their respective first canonical variates The signs were reversed for dribbling and defensive movements since lower scores correspond to better performances.

Figure 3.—Correlations of functional and skill characteristics with their respective first canonical variates. The sign were reversed for dribbling and defensive movements since lower scores correspond to better performances.

basketball players were above the respective 75th percentiles for each sample. Mean weights of the players were also above the 75th percentiles of the US, Azores and Madeira references.

A recent study of Australian state and national level basketball players suggested that adolescents 14-17 years tended to be recruited on the basis of height, while young adult athletes were selected largely on the basis of sport-specific skills.[26] Moreover, sport-specific skills are strong correlates of talent in team sports.[27] In the current study, about 40% of the athletes showed statures above the age-specific 75% percentiles of US reference data. An issue of relevance, therefore, is the basketball skills of taller and shorter youth players. To this end, the functional capacities and basketball skills of players with heights >75th percentiles, between the 25th and 75th percentiles, and <25th percentiles of US reference data were profiled (Figure 4). The tallest players did not attain better scores in skill tests but performed better in the hand grip and 2-kg ball throw tests. It would be of interest to differentiate early-maturing players who are tall and heavy from those who are tall and normal weight or tall and light.

The first canonical correlation extracted between functional capacities and basketball skills highlighted an association between abdominal muscular strength and endurance (sit-ups) and aerobic endurance on one hand, and the four skill tests, on the other. Improvement of the two endurance-based functional attributes that were independent of pubertal maturation may contribute to enhanced basketball-specific skills. Interventional studies are needed to confirm the influence of strength and endurance on skills.

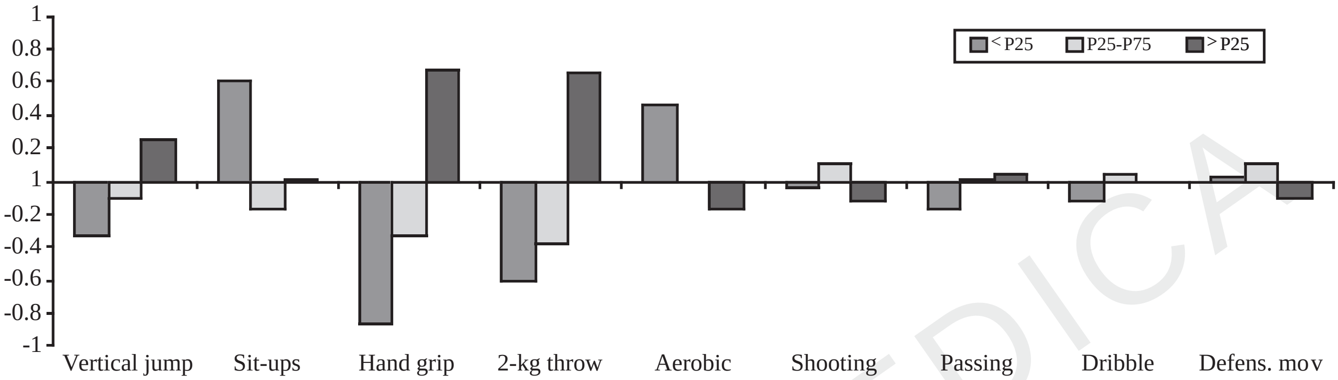

Figure 4.—Z-scores for functional capacities and basketball skills of players group by height status relative to US reference values. The signs were reversed for dribbling and defensive movements.

Mean differences between early and late pubertal subjects were 16.2 cm in height and 16.6 kg in weight, emphasizing the role of maturity status in variability of body size. Moreover, 12-year-old players in stage 3 of pubic hair were slightly taller than 13-year-old subjects in stage 2, and the younger late pubertal subjects (PH4) were 8.6 cm taller than their older peers at PH3 (Figure 5).

Although ages of the youth players spanned only two years, age per se had a significant effect on most functional capacities. Hence, the influence of pubertal status was also examined after controlling for chronological age. With the effects of age statistically removed, muscular strength and power were significantly affected by stage of pubertal maturation while the 20-meter multistage shuttle and abdominal muscular strength and endurance did not show a similar pattern of variation with maturity.

Analytical and manipulative skills are important components of success in basketball. In other team sports, such as soccer,[28] skills discriminated Belgian youth players grouped as elite, sub-elite and non-elite in under-13 and under-14 categories. In the present study, the tallest basketball players were not more skilled than other players. The promotion of tall young basketball players thus may not be incompatible with long-term success. The selection of biologically advanced subjects can be myopic since they may have a transient size and strength advantage that was unrelated to basketball-specific skills in this sample of youth players. Since the Belgian soccer tudy suggested that success in early years of sport experience was influenced by motor proficiency, patience of coaches

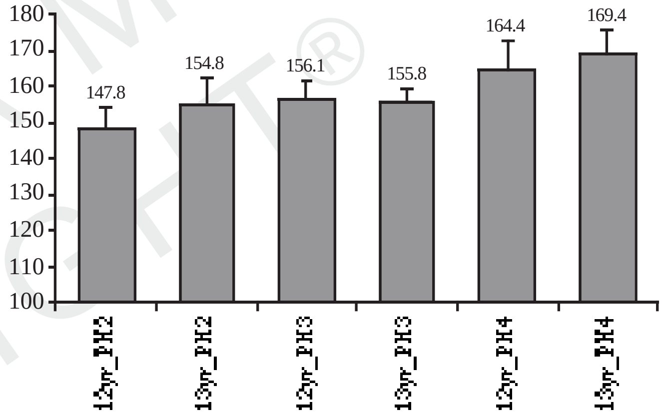

Figure 5.—Heights (cm) of basketball players of different chronological ages but at the same stage of pubic hair.

is required and perhaps more time should be devoted in the improvement of abdominal muscular strength and endurance aerobic fitness. On the other hand, low levels of subcutaneous fat combined with high scores in jumping, shooting, passing and dribbling were predictors of career progress from initiates to juveniles.[2] In the current study, when age was statistically controlled, these items were independent of maturation.

Conclusions

In summary, the effect of pubertal status on functional capacities was significant for power reflected in vertical jumps and upper limb strength. Canonical correlations showed an inverse relationship of height and subcutaneous adiposity with skill tests, and a positive relationship of abdominal muscular strength and aerobic endurance with skill tests. Pubertal status explained a significant portion of variance in body size, which may be beneficial to upper limb strength and power as measured in this study. However, abdominal muscular strength and aerobic endurance were unrelated to pubertal status. The tallest group of basketball players did not attain better scores in sport-specific skill tests.

References

1. Hoare DG. Predicting success in junior elite basketball players-the contribution of anthropometic and physiological attributes. J Sci Med Sport 2000;3:391-405.
2. Gonçalves CE, Figueiredo A, Coelho e Silva MJ. Multidimensional analysis of drop-out in youth basketball: two-year follow-up among Portuguese initiates. In: Jurimae T, Armstrong N, Jurimae J, editors. Children and Exercise XXIV. London: Routledge; 2009. p. 190-3.
3. Filliard JR, Bosc G, Irlinger P, Szczesny S. Développement physique et moteur des enfants pratiquant le basket-ball - approche longitudinal entre 11 et 14 ans. Paris: INSEP; 1994.
4. Filliard JR, Pineau JC, Szczezny S. Growth of very tall subjects - applications to a group of basketball players. Cahiers d'Anthropologie et Biométrie Humaine 1996;14:567-79.
5. Malina RM. Physical growth and biological maturation of young athletes. Exerc Sport Sci Rev 1994;22:389-433.
6. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity, 2nd edition. Champaign, IL: Human Kinetics; 2004.
7. Clarke HH. Physical and motor tests in the Medford boys growth study. Englewood Cliffs, NJ Prentice-Hall; 1971.
8. Osterback LL, Viitasalo J. Growth selection of young boys participating in different sports. In: Rutenfranz J, Mocellin R, Klimt F, editors. Children and Exercise XII. Champaign, IL: Human Kinetics; 1986. p. 373-80.
9. Claessens A, Boutmans J, Beunen G. Body structure, somatotype, motor fitness of young Belgian basketball players of different competitive levels. Anthrop Kozl 1986;30:227-31.
10. Ioakimidis P, Gerodimos V, Kellis E, Alexandris N, Kellis S. Combined effects of age and maturation on maximum isometric leg press strength in young basketball players. J Sports Med Phys Fitness 2004;44:389-97.
11. Buchanan PA, Vardaxis VG. Sex-related and age-related differences in knee strength of basketball players ages 11-17 years. J Athl Train 2003;38:231-7.
12. Zwierko T, Lesiakowski P, Florkiewicz B. Selected aspects of motor coordination in young basketball players. Human Movement 2005;6:124-8.
13. Balciunas M, Stonkus S, Abrantes C, Sampaio J. Long term effects of different training modalities on power, speed, skill and anaerobic capacity in young male basketball players. J Sports Sci Med 2006;5:163-70.
14. Castagna C, Impellizzeri FM, Rampinini E, D'Ottavio S, Manzi V. The Yo-Yo intermittent recovery test in basketball players. J Sci Med Sport 2008;11:202-8.
15. Ugarkovic D, Matavulj D, Kukolc M, Jaric S. Standard anthropometric, body composition and strength variables as predictors of jumping performance in elite junior athletes. J Strength Cond Res 2002;16:27-30.
16. Nedeljkovic A, Mirkov DM, Kukolj M, Ugarkovic D, Jaric S. Effect of maturation on the relationship between physical performance and body size. J Strength Cond Res 2007;21(1):245-250.
17. Tanner J. Growth at adolescence, 2nd edition. Oxford: Blackwell Scientific Publications; 1962.
18. Bosco C, Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. Eur J Appl Physiol Occup Physiol 1983;50:273-82.
19. Leger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1988;6:93-101.
20. Apostolidis N, Nassis GP, Bolatoglou T, Geladas ND. Physiological and technical characteristics of elite young basketball players. J Sports Med Phys Fitness 2004;44:157-63.
21. Kirkendall D, Gruber J, Johnson R. Measurement and evaluation for physical educators. Champaign, IL Human Kinetics; 1987.
22. Coelho e Silva MJ, Figueiredo AJ, Carvalho HM, Malina RM. Functional capacities and sport-specific skills of 14- to 15-year-old male basketball players: Size and maturity effects. Eur J Sport Sci 2008;8:277-85.
23. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Felgal KM, Guo SS, Wei R *et al.* CDC growth charts: United States. Volume 2008: Vital and Health Statistics; 2000.
24. Sobral F, Coelho e Silva MJ. Açores 1999: estatísticas e normas de crescimento e aptidão física. Coimbra: Direcção Regional de Educação Física e Desporto da Secretaria Regional de Educação da Região Autónoma dos Açores. Faculdade de Ciências do Desporto e Educação Física da Universidade de Coimbra 2001.
25. Freitas D, Maia J, Beunen G, Lefevre J, Claessens A, Marques A *et al.* Crescimento somático, maturação biológica, aptidão física, actividade física e estatuto sócio-económico de crianças e adolescentes madeirenses - o estudo de crescimento da Madeira. Funchal: Universidade da Madeira; 2002.
26. Drinkwater EJ, Hopkins WG, McKenna MJ, Hunt PH, Pyne DB. Modelling age and secular differences in fitness between basketball players. J Sports Sci 2007;25:869-78.
27. Pearson DT, Naughton GA, Torode M. Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. J Sci Med Sport 2006;9:277-87.
28. Vaeyens R, Malina RM, Janssens M, Van Renterghem B, Bourgois J, Vrijens J *et al.* A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. Br J Sports Med 2006;40: 928-34.