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Anthropometry and performance of top youth international male basketball players in Spanish national academy

Características antropométricas y de rendimiento de jugadores internacionales junior de baloncesto de la academia española de baloncesto Siglo XXI

Julio Calleja-González[1], Juan Mielgo-Ayuso[2], José Antonio Lekue[3], Xabier Leibar[3], Julen Erauzkin[3], Igor Jukic[4], Sergej M. Ostojic[5], Jesús Gustavo Ponce-González[6], Maite Fuentes-Azpiroz[1] and Nicolás Terrados[7]

[1]Laboratory of Human Performance. Department of Education and Sport. Faculty of Physical Activity and Sport Sciences. University of the Basque Country. Alava, Spain. [2]Department of Biochemistry, Molecular Biology and Physiology. School of Physical Therapy. University of Valladolid. Soria, Spain. [3]Centro de Perfeccionamiento Técnico de Fadura. Dirección de Deportes. Gobierno Vasco. Spain. [4]Sports Diagnostic Centre. Faculty of Kinesiology. University of Zagreb. Zagreb, Croatia. [5]Centre for Health, Exercise and Sport Sciences. Exercise Physiology Lab. Belgrade, Serbia. [6]MOVE-IT Research Group. Department of Physical Education Sciences. Universidad de Cádiz. Cádiz, Spain. [7]Unidad Regional de Medicina Deportiva del Principado de Asturias -Fundación Deportiva Municipal de Avilés y Departamento de Biología Funcional. University of Oviedo. Asturias, Spain

Abstract

The "Century XXI" Project is a seven-year intervention sport program performed among the best Spanish youth basketball players, who were assigned to one of the following intervention groups based on the following criteria: age, position, mature level, and origin in the country. The study was performed (1996-2001) with a total of 90 players. The main purposes of this study were: a) to describe anthropometric and performance characteristics of top youth international male basketballers in the Spanish national academy; and b) to analyze differences among positions. In summary, the main findings of this study were: a) the anthropometry presented significant differences between groups under (U-) 14 and U-17; and b) in the U-17 group centers presented more arm span. In our study, the most significant changes are in U-16 *vs* U-14 and U-15 in strength body up values, and the best result in endurance capacity took place in June of the fourth year. Within this context, the results of the present study may be useful for strength and conditioning coaches to plan their programs with youth basketball players.

Key words:

Basketball. Sport. Performance. Kinanthropometry.

Resumen

El Proyecto Siglo XXI es un programa deportivo de intervención de siete años realizado con los mejores jugadores de baloncesto juveniles españoles, que fueron asignados a uno de los siguientes grupos de intervención según los siguientes criterios: edad, posición, nivel de madurez y origen en el país. El estudio se realizó entre 1996 y 2001 con un total de 90 jugadores. Por ello, el propósito principal de este estudio fue: a) describir las características antropométricas y de rendimiento de los jugadores; y b) analizar las diferencias de los jugadores en diferentes roles posicionales en el programa de intervención. Los principales hallazgos de este estudio fueron: a) la antropometría presentó diferencias significativas entre los grupos U-14 y U-17; y b) en la medida que los jugadores crecieron, observamos más longitud del brazo. En nuestro estudio, los cambios más significativos se dan en U-16 *vs* U-14 y U-15 en valores de fuerza y el mejor resultado en la capacidad de resistencia tuvo lugar en junio del 4º año. Los resultados del presente estudio pueden ser útiles para los entrenadores y preparadores físicos para planificar sus programas con jugadores de baloncesto de categorías inferiores en planes a largo plazo.

Palabras clave:

Baloncesto. Deporte. Rendimiento. Cineantropometría.

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Correspondence:

Juan Mielgo Ayuso. Department of Biochemistry, Molecular Biology and Physiology Faculty of Physical Therapy. Campus Universitario de Soria. Universidad de Valladolid. 42004 Soria, Spain
e-mail: juankaya@msn.com

INTRODUCTION

Basketball is one of the most famous team sport games played in almost every country worldwide (1) that has undergone quite radical changes in the past decade (2). Games are characterized by repeated explosive activities, such as sprints, jumps, shuffles and rapid changes in direction (3). To perform under these physiological demands, players need to develop many fitness components including particularly muscular power (4). The athletes' performance is directly related to their capacity to stand several stop-and-go efforts, as well as to their power and speed capacities (5). Moreover, basketballers perform about 997 changes of direction during a 48-minute game, with an average time at each position of about three seconds. According to the literature, on elite 85 men's basketballers perform around 1,000 changes of movement every 2.0 s with a 1:3 work to rest ratio (5). These studies clearly indicate that the game is characterized by intermittent activity, as well as rapid and frequent changes in the players' movement patterns (6). Besides technical and tactical skills, muscular strength and "explosive" leg power are indeed the most important factors contributing to successful performance during elite competitions (7). Anyway, other studies have consistently suggested that success appears to be more dependent upon the player's anaerobic capabilities than on their aerobic capabilities (8), although this may be influenced by the player's position and the level of competition (2). During the last years, scientific evidence has been published about physiology, conditioning focus on basketball (9,10). However, previous studies have assessed anthropometric and conditional profiles of successful basketballers. Preceding research has evaluated ideal physiological and anthropometric profiles of successful basketball players, mostly from North America) (1), France (11), Serbia (1), Spain with first league players (12), and England with university female players (13).

Although there is a lack of descriptive information regarding the characteristics of elite youth players, particularly about the evolution of capacities, the morphology and anthropometry of players could be one of the most important aspects that have contributed to the success of the Spanish national basketball teams during the last decade. Aspects such as experience, body composition, endurance, and balance between anaerobic and aerobic power are of primary importance in evaluating elite players (1). These intensive long-term programs present special interest for the Basketball Clubs Association (ACB) teams. Unquestionably, understanding selection criteria comes to be the essential factor to recruit future basketball players, when our best generation of players born in the eighty years. Besides during the last years, Spanish basketballers and coaches have been top elite in international championships. In particular, the best international results of the Spanish national team (three European championships won, two silver medals in Olympic Games and one World Championship), has reached players to the best league National Basketball Association (NBA). However, to the author's knowledge, no evidence has been reported about long term developed athlete programs in basketball. Besides, these programs have been developed throughout adolescence. During these years (14-17 years), basketballers grow in relation to measurable changes in size, physique and body composition and various systems of the body, whereas maturation refers to progress toward the mature state. Maturation is variable among bodily systems and also in timing and tempo of progress. The processes of growth and maturation are related, and both influence physical performance (14). For that reason, the main purpose of this longitudinal study was: a) to describe anthropometric and performance characteristics of top youth international male basketballers in a Spanish national academy at different age stages; and b) to analyze differences among positions. The results presented after finishing the project were: one NBA player, three in the national A Team, ten in ACB (first Spanish league), five in Spanish Basketball League LEB (second league) and 39 in LEB-2 (third League), Spanish Amateur Basketball League EBA (fourth league). Understanding the profile of successful players could give coaches, trainers and exercise scientist's better working knowledge of this particular group of athletes (1).

METHODS

PARTICIPANTS

Ninety youth male basketball players participated in this longitudinal study. According to their competition category, the participants were divided into four groups: a) cadet (year 1) (U-14, n = 28); b) cadet (year 2) (U-15, n = 27); c) junior (year 1) (U-16, n = 20); and d) junior (year 1) (U-17, n = 15), who played in the "Century XXI" Project of the Spanish Basketball Federation. During the period of the study all players changed their game position given that they were in an academy developed program. The percentage of distribution of training per year has been shown in previous article (15).

Players were recruited after a selective talent process by methods of diverse advertisements using standard criteria (technical, tactical, biomedical and physical conditional) and renovated year per year. All athletes completed a medical questionnaire and an electrocardiographic and cardiopulmonary examination. None of the participants involved in this research smoked, drank alcohol, nor were taking any medication known to alter hormonal response nor had any pre-existing injuries prior to testing. Furthermore, participants followed a similar diet that was constantly supervised by the dietician and all of them performed the same training program and competitions. The voluntary participants who fulfilled the inclusion and exclusion criteria and passed the baseline physical and biomedical examination were stratified by age ranges and categorized into the groups based on chronological age (15). Inclusion criteria comprised being male (14, 15, 16, 17 years), living in Spain, being basketball players or having some active sport lifestyles in other sports, and being non-smokers (16). On the other hand, the exclusion principles were suffering from physical (injuries, stroke, illness, etc.) and/or psychological problems that may have precluded the performance of the requested strength or endurance training, that could influence on physical performance or the interpretation of the results, having a history of systematic

strength/endurance training (moderate to high intensity training more than once a week) in the year before the beginning of the study (17). The protocols and procedures of the "Century XXI" Project were in agreement with the ethical guidelines on biomedical research on human subjects of the World Medical Association's Declaration of Helsinki (2008). Before participation, all players, as well as their parents and coaches, were carefully informed about the possible risks and benefits of the project, being required to read and sign an institutionally approved informed consent document. Since participants were children, their parents signed an informed consent. Data information obtained was considered as confidential following current Spanish legislation regulating personal data protection (Spanish Organic Law 15/1999 and Royal Decree 1720/2007). This trial was registered at the Spanish basketball Federation and Basque Government. Access to the database was restricted to the researchers that participated in the "Century XXI" Project and co-workers (15).

MEASURES

The assessments took place at the Fadura High Performance Center (Basque Government, Vizcaya, Spain) for participants during the intervention period. Physiological, anthropometry, maturation, fitness tests were controlled four times per year (September, December, April, June) during four years (16 moments), for all players.

EXERCISE PROTOCOLS

All practice sessions were carefully supervised by certified trainers (two directors, three basketball coaches, one strength and conditioning coach, two team physicians, one psychologist).

ANTHROPOMETRICAL MEASUREMENTS

Anthropometric measurements were taken following the International Society for the Advancement of Kineanthropometry (ISAK) protocol by the same certified anthropometrist (18,19). The following measurements were performed: body mass, height, and arm span. Skinfolds (triceps, abdominal, suprailiac, front thigh, subscapular and peroneal) were measured to calculate the sum of four and six skinfolds and estimate fat mass by Carter equation (% fat mass = 0.1051* (triceps + abdominal + suprailiac + front thigh + subscapular + peroneal skinfolds) + 2.58 (20).

FITNESS TEST

All measurements were taken at the finalization of the training cycles (recovery microcyle) to limit differences in training status and/or intensity (21). All test procedures were performed by the same strength and conditioning coach. The players were familiar with all test procedures that had been previously performed. Testing day was undertaken between 18:00 and 20:00 h, at least 24 h after the last training session and 2 h post-prandial. All fitness tests were performed in an indoor sports hall with temperature (21.2-23.00°) and relative humidity (44.4-51.0%), measured by a Wireless Full Weather Station (Oregon, Scientific, WMRI, 80, 3.0).

Prior to each training session each subject started with a 20-minute standardized warm-up routine (10-min jogging and 10-min jumping jacks and jumping rope) and accelerations, changing directions with injury prevention drills consisting of general movements and dynamic (22). Players underwent the physical performance tests, followed by the session routine, and concluded with a 15-minute cool down routine. Players performed the following fitness tests (15):

- *Speed 20 m:* the running speed of players was evaluated with a 2 x 20 m sprint test.
- *3*10 shuttle run test:* to know the ability and coordination of players, they ran back and forth as fast as possible crossing each line with both feet every time. This was performed three times, covering a total distance of 30 m (3*10 m). Every time the basketballer crossed any of the lines, he picked up (the first time) or exchanged (second and third time) a sponge, which was previously placed behind the lines.
- *Overhead medicine ball throw (OMBT) 3, 4, 5 kg:* to evaluate the upper-body muscular power**,** players threw the ball over their head behind them as far as possible.
- *Low back dynamometer:* to test dynamic and static lumbar endurance, a backup lumbar extension dynamometer was used. This test measures back strength, which is important in core stability and for preventing lower back pain.
- *Counter movement jump (CMJ):* to assess jumping ability, CMJ is commonly used in the assessment of basketball players' physical fitness.
- *Abalakov:* Abalakov jump is used to assess leg power.
- *Horizontal jump test standing long jump (SLJ):* this test was performed as described elsewhere. Participants performed two practice trials and then two test trials separated by one-minute rest. The distance, measured to the nearest 0.01 m, was considered as the horizontal displacement of the feet between the starting line and the point where the back heel contacted the floor. Only the best result was considered for analysis.
- *Crunch 30 SG:* to evaluate abdominal muscle strength and endurance, players performed a one-minute bent-knee sit-up test (crunch test).
- *Course-Navette:* to evaluate physical endurance fitness.
- *Seat and reach test:* this test is commonly used in health related and physical-fitness test batteries to evaluate the hamstring and lower back flexibility.

STATISTICAL ANALYSIS

The standard statistical parameters (M, SD, range and percentiles) were calculated for each physical performance test and

anthropometrical assessment. The Shapiro-Wilk normality test was used to check normality. Parametric test and Levene's test of homogeneity of variance were applied. Therefore, a parametric analysis was applied, and one-way analysis of variance (ANOVA) was used to determine significant differences among positions in anthropometric and performance characteristics with a Bonferroni post-hoc comparison. The players were divided based on their playing position and the same statistical approaches in each group were applied. Pearson correlation was used between anthropometrical measurements and performance test. To overestimate effect sizes, values were interpreted according to Ferguson (2009) as no effect if $0 \leq 2p < 0.05$; a minimum effect if $0.05 \leq 2\ p < 0.26$; a moderate effect if $0.26 \leq 2p < 0.64$; and a strong effect if $2\ p \geq 0.64$ (23). Statistical analyses were performed using the SPSS Statistics package v22.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set at $p < 0.05$.

RESULTS

Table I shows the anthropometric variables and body composition and physical performance in each age stage**.** There are significant differences ($p < 0.001$) among groups. Concretely, there are significant differences between U-15 and U-17 and between U-15 and U-16 *versus* U-18 in body mass, height and arm span, presenting higher values in older players. However, no differences in fat mass values were found. Anyway, there are not differences between ($p > 0.05$) age stages regarding ∑ of 4 and ∑ of 6 skinfolds and FM (%).

Regarding physical performance tests, there are significant differences ($p < 0.05$) among groups in all performance tests except for the flexibility test. Concretely, there are significant differences between U-18 and U-15 in every test except for the 3 x 10 and flexibility tests, showing better values in U-18 in these parameters. Likewise, U-15 showed significant differences in 5 kg and 3 kg, extensors, horizontal jump and crunch tests compared to U-16, U-17 and U-18. The U-18 group presented significant t differences in comparison with U-15 and U-16 and in 3 kg, and *versus* U-17. In the Course-Navette test, the U-18 players improved performance *versus* U-15 players. In the jump test, significant differences were observed between U-15 and U-18.

Table II shows body composition and physical performance of U-15 based on playing position. In this way, we only observed that the centers were slower than guards and presented slower performance in throwing (3 kg).

Table III describes body composition and physical performance of U-16. Only presented significant differences in body mass between center and guards (71.9 ± 6.7 *vs* 82.7 ± 9.8 kg; $p = 0.032$).

Table I. Body composition and physical performance of basketball players

	U-14 (n = 41)	U-15 (n = 43)	U-16 (n = 41)	U-17 (n = 24)	p	η^2_p
Age (years)	14.16 ± 0.45	15.20 ± 0.46*	16.17 ± 0.47*,†	17.30 ± 0.45*,†,‡	< 0.001	0.851
Body mass (kg)	74.0 ± 9.1	78.9 ± 9.7	84.9 ± 8.1*	87.8 ± 9.5*,†	< 0.001	0.246
Height (cm)	189.2 ± 5.6	192.0 ± 5.4	195.6 ± 5.0*	196.4 ± 4.8*,†	< 0.001	0.229
Arm span (cm)	192.5 ± 6.0	195.3 ± 6.01	199.5 ± 6.46*	201.1 ± 7.76*,†	< 0.001	0.209
∑-4 (mm)	37.2 ± 9.6	37.6 ± 16.4	42.2 ± 17.1	36.3 ± 14.6	0.542	0.023
∑-6 (mm)	59.2 ± 16.3	58.6 ± 24.5	63.5 ± 23.5	54.2 ± 21.3	0.605	0.020
FM (%)	8.9 ± 1.8	14.3 ± 21.0	9.3 ± 2.5	8.3 ± 2.2	0.238	0.044
20 m (sec)	3.19 ± 0.33	2.97 ± 0.22	2.92 ± 0.23*	3.04 ± 0.32	0.013	0.134
3 x 10 m (sec)	7.50 ± 0.54	7.37 ± 0.57	7.05 ± 0.41	6.96 ± 0.86	0.025	0.116
5 kg (m)	5.66 ± 0.77	6.22 ± 0.59*	6.56 ± 0.80*	7.20 ± 0.68*,†	< 0.001	0.364
4 kg (m)	6.37 ± 0.78	6.87 ± 0.66	7.17 ± 0.87*	8.02 ± 0.94*,†	< 0.001	0.348
3 kg (m)	6.99 ± 0.73	7.72 ± 0.97*	7.93 ± 1.15*	9.03 ± 1.26*,†,‡	< 0.001	0.334
Back extensors (N)	142.6 ± 28.7	173.4 ± 27.0*	193.1 ± 28.1*	207.7 ± 31.1*,†	< 0.001	0.430
CMJ (cm)	32.62 ± 4.50	36.26 ± 4.91	39.26 ± 6.14*	41.57 ± 7.08*,†	< 0.001	0.275
Abalakov (cm)	39.38 ± 4.73	43.00 ± 7.42	46.26 ± 7.36*	47.07 ± 8.19*	0.002	0.175
Horizontal jump (m)	2.02 ± 0.27	2.24 ± 0.22a	2.25 ± 0.21*	2.40 ± 0.19*	< 0.001	0.251
Course-Navette (paliers)	9.85 ± 1.94	10.57 ± 1.85	10.90 ± 1.60	11.61 ± 1.89*	0.033	0.105
Flexibility (cm)	8.16 ± 14.17	6.81 ± 9.27	3.83 ± 9.62	8.40 ± 12.28	0.609	0.021
Crunch test (rep)	23.04 ± 4.09	26.46 ± 3.37*	28.12 ± 3.66*	28.67 ± 2.74*	< 0.001	0.287

Data are expressed as mean ± SD. Significantly differences among age categories by one-way ANOVA and Bonferroni post-hoc *test (p < 0.05): *vs cadet 1; †vs cadet 2; ‡vs junior 1.*

Table II. Body composition and physical performance of U-15 basketball players

	Guard (n = 14)	Forward (n = 12)	Centre (n = 15)	p	η^2_p
Age (years)	14.12 ± 0.41	14.21 ± 0.56	14.16 ± 0.41	0.869	0.007
Body mass (kg)	69.0 ± 6.9	78.0 ± 9.8	75.2 ± 9.2	0.144	0.162
Height (cm)	185.4 ± 3.7	*191.4 ± 3.9**	*191.1 ± 6.8*	*0.024*	0.249
Arm span (cm)	188.6 ± 4.8	195.3 ± 4.3	193.9 ± 6.7	0.060	0.235
∑-4 (mm)	35.4 ± 8.6	38.5 ± 8.3	38.1 ± 11.8	0.801	0.022
∑-6 (mm)	55.5 ± 15.0	61.6 ± 15.1	60.9 ± 19.2	0.746	0.029
FM (%)	8.4 ± 1.6	9.1 ± 1.6	9.3 ± 2.1	0.596	0.048
20 m (sec)	2.95 ± 0.17	3.19 ± 0.32	*3.36 ± 0.33**	*0.021*	0.296
20 mB (sec)	3.28 ± 0.34	3.36 ± 0.29	3.60 ± 0.40	0.165	0.151
3 x 10 m (sec)	7.31 ± 0.46	7.71 ± 0.55	7.54 ± 0.60	0.431	0.081
5 kg (m)	5.94 ± 0.49	5.50 ± 1.06	5.52 ± 0.78	0.386	0.073
4 kg (m)	6.68 ± 0.64	6.46 ± 0.76	6.03 ± 0.85	0.162	0.136
3 kg (m)	7.35 ± 0.62	7.16 ± 0.62	*6.54 ± 0.69**	*0.024*	0.259
Back extensors (n)	149.6 ± 35.4	141.1 ± 26.8	137.1 ± 24.0	0.618	0.038
CMJ (cm)	33.89 ± 4.31	31.17 ± 4.31	32.36 ± 4.86	0.521	0.055
Abalakov (cm)	40.89 ± 3.02	41.13 ± 4.91	37.18 ± 5.23	0.126	0.165
Horizontal jump (m)	2.11 ± 0.21	2.11 ± 0.08	1.89 ± 0.35	0.102	0.167
Course-Navette (paliers)	11.11 ± 1.17	9.92 ± 0.86	8.77 ± 2.00a	0.020	0.287
Flexibility (cm)	8.15 ± 9.98	10.50 ± 21.60	6.69 ± 12.88	0.866	0.011
Crunch test (rep)	24.00 ± 4.40	22.57 ± 3.87	22.45 ± 4.16	0.664	0.032

Data are mean ± SD. Significant difference from the respective positional group according to Bonferroni post-hoc *test: ** vs *guard.*

Table III. Body composition and physical performance of U-16 basketball players

	Guard (n = 14)	Forward (n = 10)	Centre (n = 19)	p	η^2_p
Age (years)	15.15 ± 0.43	15.27 ± 0.58	15.20 ± 0.44	0.815	0.010
Body mass (kg)	71.9 ± 6.7	78.9 ± 8.7	*82.7 ± 9.8**	*0.032*	0.218
Height (cm)	188.9 ± 3.2	193.8 ± 3.8	193.1 ± 6.5	0.088	0.150
Arm span (cm)	192.2 ± 4.9	195.7 ± 6.3	196.7 ± 6.1	0.224	0.105
∑-4 (mm)	32.1 ± 3.0	45.2 ± 27.8	36.6 ± 12.1	0.273	0.086
∑-6 (mm)	50.4 ± 5.5	70.8 ± 40.0	56.5 ± 18.9	0.231	0.096
FM (%)	7.9 ± 0.6	10.0 ± 4.2	20.0 ± 29.5	0.345	0.073
20 m (sec)	2.91 ± 0.09	2.91 ± 0.19	3.03 ± 0.28	0.433	0.084
20 mB (sec)	3.13 ± 0.42	3.27 ± 0.44	3.37 ± 0.34	0.438	0.083
3 x 10 m (sec)	7.21 ± 0.43	7.70 ± 0.66	7.38 ± 0.62	0.306	0.098
5 kg (m)	6.31 ± 0.42	5.98 ± 0.48	6.24 ± 0.77	0.605	0.043
4 kg (m)	7.24 ± 0.57	6.68 ± 0.27	6.62 ± 0.73	0.071	0.206
3 kg (m)	7.94 ± 0.80	7.63 ± 0.49	7.56 ± 1.26	0.672	0.034
Back extensors (n)	183.0 ± 21.6	172.6 ± 27.2	164.2 ± 30.7	0.272	0.103
CMJ (cm)	36.86 ± 4.49	36.00 ± 3.46	36.00 ± 5.80	0.935	0.007
Abalakov (cm)	44.86 ± 4.71	45.50 ± 5.97	41.08 ± 8.94	0.449	0.077
Horizontal jump (m)	2.27 ± 0.22	2.32 ± 0.08	2.17 ± 0.25	0.395	0.075
Course-Navette (paliers)	11.79 ± 1.47	10.00 ± 2.38	10.00 ± 1.64	0.105	0.211
Flexibility (cm)	9.59 ± 5.47	9.75 ± 17.11	3.29 ± 8.46	0.215	0.120
Crunch test (rep)	26.82 ± 3.28	27.60 ± 2.70	25.67 ± 3.75	0.524	0.050

Data are mean ± SD. Significant difference from the respective positional group according to Bonferroni post-hoc *test: ** vs *guard.*

Table IV shows body composition and physical performance of U-17 based on playing position. Centers described higher values in height (190.4 ± 3.2 *vs* 198.8 ± 3.0 cm; $p < 0.001$) and arm span (193.4 ± 5.5 *vs* 202.9 ± 5.0 cm; $p = 0.007$) than guards.

Table V described body composition and physical performance of U-18 basketball players. In this table, differences were observed between canters and guards in body mass (79.3 ± 3.6 *vs* 92.6 ± 9.2 kg; $p = 0.031$) and (191.2 ± 3.5 *vs* 199.9 ± 2.8; $p = 0.001$).

DISCUSSION

For the best of the author's knowledge, this is the first study investigating complete physiological, anthropometric and performance characteristics of top youth international male Spanish basketballers, with no previous evidence regarding national academy during four-year follow-up program. The main purpose of this study was: a) to describe anthropometric and performance characteristics of this population; and b) to analyze differences among positions. The main findings of this study were the following. The anthropometry presented significant differences between groups U-14 and U-17. In the mediated that players grew, more arm span was observed. Likewise, the most significant changes were in U-17 *vs* U-14 and U-15 in strength upper body values. Finally, the best result in endurance capacity took place in June of the 4th year in Course-Navette.

The "Century XXI" Project was a long-term program performed with the best U-14 and U-17 Spanish players with the aim of improving sports performance in order to be elite basketballers (15). One of the strengths of this experience was its multidisciplinary approach. A big group of professionals (coaches, physicians, psychologist, and strength and conditioning coaches), with expertise in a specific field (basketball, conditioning and fitness, medicine, psychology), designed it together.

From an anthropometrical point of view, in basketball, height is considered to be the most important physical attribute. In particular, this parameter is an important factor when identifying and selecting talents (24). Differences among playing positions in height and body mass of elite basketball players have been shown in several previous studies (1). The first result of our data confirmed significant differences in body mass between two categories (U-15 and U-17) and this idea is in accordance with previous studies providing a better understanding to basketball specialists regarding the selection process of players at the elite level, especially on the transition from youth elite programs to men's elite leagues (25). The knowledge of body composition and fitness level of the players and their evolution through the season is very helpful for the head coach, as well as for the strength and conditioning coach (26).

In the same sense, in the mediated those players grew, more height, more body mass and more arm span were observed. With-

Table IV. Body composition and physical performance of U-17 basketball players

	Guard (n = 14)	Forward (n = 10)	Centre (n = 16)	p	η^2_p
Age (years)	16.08 ± 0.41	16.33 ± 0.64	16.14 ± 0.39	0.432	0.044
Body mass (kg)	78.7 ± 8.0	84.8 ± 6.9	88.1 ± 7.6	0.061	0.216
Height (cm)	190.4 ± 3.2	195.3 ± 5.0	*198.8 ± 3.0**	*< 0.001*	0.478
Arm span (cm)	193.4 ± 5.5	199.0 ± 6.0	*202.9 ± 5.0**	*0.007*	0.349
∑-4 (mm)	40.1 ± 20.5	46.9 ± 17.0	40.0 ± 16.4	0.659	0.036
∑-6 (mm)	61.7 ± 30.0	71.2 ± 20.3	59.4 ± 22.8	0.554	0.050
FM (%)	9.1 ± 3.2	10.1 ± 2.1	8.8 ± 2.4	0.551	0.050
20 m (sec)	2.84 ± 0.18	2.89 ± 0.18	2.99 ± 0.30	0.531	0.086
20 mB (sec)	2.94 ± 0.21	3.03 ± 0.16	3.17 ± 0.27	0.217	0.196
3 x 10 m (sec)	6.94 ± 0.36	7.21 ± 0.62	7.06 ± 0.38	0.431	0.081
5 kg (m)	6.88 ± 0.52	5.95 ± 0.73	6.53 ± 0.96	0.167	0.190
4 kg (m)	7.67 ± 0.73	6.83 ± 0.85	6.95 ± 0.91	0.227	0.191
3 kg (m)	8.33 ± 0.76	7.95 ± 1.41	7.58 ± 1.32	0.529	0.087
Back extensors (n)	205.5 ± 18.6	197.8 ± 46.4	179.7 ± 19.2	0.251	0.179
CMJ (cm)	39.25 ± 5.52	40.75 ± 4.92	38.43 ± 7.93	0.849	0.020
Abalakov (cm)	45.63 ± 6.63	47.25 ± 6.45	46.43 ± 9.45	0.941	0.008
Horizontal jump (m)	2.33 ± 0.17	2.23 ± 0.21	2.19 ± 0.25	0.484	0.098
Course-Navette (paliers)	11.93 ± 1.30	10.75 ± 0.96	10.17 ± 1.71	0.084	0.253
Flexibility (cm)	7.63 ± 3.46	7.67 ± 14.50	-2.14 ± 10.48	0.104	0.260
Crunch test (rep)	28.67 ± 3.67	28.00 ± 2.45	27.71 ± 4.57	0.906	0.014

Data are mean ± SD.Significant difference from the respective positional group according to Bonferroni post-hoc *test: ** vs *guard.*

Table V. Body composition and physical performance of U-18 basketball players

	Guard (n = 6)	Forward (n = 8)	Centre (n = 10)	p	η^2_p
Age (years)	17.42 ± 0.11	17.33 ± 0.70	17.20 ± 0.32	0.639	0.042
Body mass (kg)	79.3 ± 3.6	87.6 ± 9.0	92.6 ± 9.2*	0.031	0.353
Height (cm)	191.2 ± 3.5	195.5 ± 3.9	199.9 ± 2.8*	0.001	0.596
Arm span (cm)	195.1 ± 6.7	200.3 ± 6.4	204.9 ± 7.3	0.064	0.291
∑-4 (mm)	28.9 ± 4.6	46.1 ± 21.4	33.0 ± 9.4	0.186	0.228
∑-6 (mm)	43.1 ± 6.5	69.1 ± 29.7	49.1 ± 14.5	0.156	0.249
FM (%)	7.1 ± 0.7	9.8 ± 3.1	7.7 ± 1.5	0.156	0.249
20 m (sec)	3.06 ± 0.46	2.88 ± 0.06	3.08 ± 0.27	0.762	0.048
20 mB (sec)	2.95 ± 0.12	3.05 ± 0.06	3.29 ± 0.33	0.123	0.317
3 x 10 m (sec)	6.86 ± 0.45	6.77 ± 0.04	7.08 ± 1.15	0.870	0.023
5 kg (m)	7.28 ± 0.64	6.85 ± 0.78	7.24 ± 0.75	0.757	0.045
4 kg (m)	8.11 ± 1.17	7.85 ± 0.49	8.01 ± 0.97	0.954	0.008
3 kg (m)	9.46 ± 0.83	8.55 ± 0.92	8.86 ± 1.60	0.642	0.077
Back extensors (n)	215.4 ± 27.5	213.5 ± 29.0	201.5 ± 035.8	0.736	0.050
CMJ (cm)	46.60 ± 3.51	36.50 ± 7.78	39.43 ± 7.44	0.118	0.322
Abalakov (cm)	49.60 ± 7.44	42.50 ± 10.61	46.57 ± 8.77	0.607	0.087
Horizontal jump (m)	2.42 ± 0.17	2.46 ± 0.13	2.36 ± 0.23	0.791	0.042
Course-Navette (paliers)	12.50 ± 1.77	13.20 ± 1.40	10.57 ± 1.77	0.111	0.330
Flexibility (cm)	14.80 ± 10.57	18.50 ± 13.44	1.88 ± 10.25	0.072	0.355
Crunch test (rep)	29.00 ± 2.35	32.00 ± 2.00	27.63 ± 2.72	0.119	0.299

Data are mean ± SD. Significant difference from the respective positional group according to Bonferroni post-hoc *test: ** vs *guard.*

ers et al. (1977) investigated the anthropometric characteristics of basketball, hockey and soccer players and found that basketball players were taller and heavier, thus presenting greater muscle mass than players of other sports (27). In particular, players showed higher body mass and arm span values compared to the general population and indoor soccer players, and the anthropometric and physical fitness characteristics differed depending on the team court sport practiced (28).

Regarding positions based on our data, it must be noted that from early ages there are morphological differences between centers and guards, which serve us as references to be able to select, although further investigations are necessary to assess potential changes in status to determine relations between anthropometrical and skill variables (29).

On the other hand, basketball is characterised by repeated explosive activities, such as sprints, jumps, shuffles and rapid changes in direction, presenting a high level of strength parameters (4). In particular, upper extremity muscle strength and grip strength are the primary factors affecting passing accuracy. Grip strength is correlated with the strength of the upper extremity, general strength of the body and some anthropometric measurements (30). In this way, the medicine ball test protocol attempts to evaluate and provide information about the ability of the players to apply strength/power. Medicine ball throwing correlates with upper-body strength as well as with throwing and hitting ability (31). This indicates that training workload is of importance in these subjects for enhancement of ball throwing performance and in designing training programs (32). In particular, in basketball the centers position being advanced in most of the medicine-ball-throw in all positions (24). In our study, the most significant changes were in U-17 *vs* U-14 and U-15 in strength values (3 kg). These results are based on previous conclusions that demonstrated that resistance training designed for young basketballers increased explosive levels (33).

The low back pain is a relatively common complaint in young team sport players (34), especially the prevalence of pain symptoms is highest during the competitive playing season. Based on this affirmation, the back-extensor extension dynamometer is commonly used to test dynamic and static lumbar area (15). Our results presented statistical differences in the U-17 group *vs* U-14 and U-15. These results can help us better understand the prevalence of low back pain and provide us with necessary insight to take effective steps towards its prevention in athletes (35); however, no clear explanation for the differences are presented (36).

The vertical jump in basketball is a good measure of specific muscular performance (1)**.** The literature reports that explosive power is an important feature for basketball players (37,38). Within this context, our data showed significant differences in the U-17 group compared to the U-14 and U-15 groups, respectively. The effect of pubertal status was significant for the jumps (39); this is

probably due to the specific nature of basketball, relying more on jumping activities as compared to other team sports.

Jumping ability in horizontal axis is very important for a basketballer, given that the player must jump as high as possible for achieving the ball during rebound task (2). In particular**,** significant differences were observed in the U-17 group *vs* U-14. Maturational differences explain the morphological superiority of national athletes in terms of arm span, lower limb length, biacromial breadth and arm strength, in consonance with other studies that demonstrated that those who are more mature have advantages in anthropometric characteristics and physiological test results (40). Maturation should be considered as a covariate when one intends to distinguish the morphological characteristics and fitness of U-16 athletes with different levels (41).

The necessary oxygen uptake for play to basketball has been established in the scientific literature on a previous compendium (42). Our data were obtained by a Course-Navette test and the values presented in this population produced improvement in the results. There are significant differences between U-14 and U-17. A tendency was observed in the U-15 group: the guards completed more periods than the rest of positions. The best result in this test took place in June of the 4th year (U-17). The increase in VO_{2max} during the pubertal age corresponds to the greater increase in height, which is in accordance with many other organic changes, increasing endurance capacity (43). The main limitation of this project was the low sample, given that the elite of this sport is being analyzed.

In summary, the main findings of this study were: a) the anthropometry presented significant differences between groups U-14 and U-17; and b) in the mediated that players grew, a bigger arm span was observed. The most significant changes were in U-16 *vs* U-14 and U-15 in strength body up. The best result in endurance took place in June of the 4th year. Within this context, the present study may be useful for strength coaches to plan their programs with youth basketballers.

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