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ANTHROPOMETRIC, AEROBIC AND MUSCLE POWER PROFILE OF YOUNG COSTA RICAN BASKETBALL PLAYERS

PERFIL ANTROPOMÉTRICO, AERÓBICO Y DE POTENCIA MUSCULAR DE JUGADORES JUVENILES DE BALONCESTO COSTARRICENSES

PERFIL ANTROPOMÉTRICO, AERÓBICO E DE POTÊNCIA MUSCULAR DE JOGADORES JUVENIS DE BASQUETE DA COSTA RICA

Randall Gutiérrez-Vargas ^{1,4,5}, José Alexis Ugalde-Ramírez ^{1,4,5}, José Pino-Ortega ⁶, José Andrés Trejos-Montoya ^{2,4,5}, Luis Blanco-Romero ^{2,5}, Braulio Sánchez-Ureña ^{2,4,5}, Juan Carlos Gutiérrez-Vargas ^{3,4,5} and Daniel Rojas-Valverde ^{1,4,5}

jose.ugalde.ramirez@una.cr

¹Centro de Investigación y Diagnóstico en Salud y Deporte (CIDISAD), Universidad Nacional, Heredia, Costa Rica

²Programa de Ciencias del Ejercicio y la Salud (PROCESA), Universidad Nacional, Heredia, Costa Rica

³Centro de Estudios para el Desarrollo del Rendimiento y la Salud (CEDERSA), Universidad Nacional, Heredia, Costa Rica

⁴Núcleo de Estudios para el Alto Rendimiento y la Salud (NARS), Universidad Nacional, Heredia, Costa Rica

⁵Escuela de Ciencias del Movimiento Humano y Calidad de Vida, Universidad Nacional, Heredia, Costa Rica

⁶Departamento de Actividad Física y Deporte, Universidad de Murcia, Murcia, España

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ABSTRACT

Gutiérrez-Vargas, R., Ugalde-Ramírez, A., Pino-Ortega, J., Trejos-Montoya, J.A., Blanco-Romero, L., Sánchez-Ureña, B., Gutiérrez-Vargas, J.C. & Rojas-Valverde, D. (2022). Anthropometric, aerobic and muscle power profile of young Costa Rican basketball players. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud**, 20(2), 1-15. The purpose of this study was to describe an anthropometric, aerobic and muscle power profile of young Costa Rican basketball players according to sex, play positions and age. The assessment was carried out on 99 young players (43 women and 56 men; 18 guards, 51 forwards and 30 centers; 42 in the U16 category and 57 in the U18 category) from eight different teams. The sports experience of the players was 6.5 ± 3.1 years. The following parameters were assessed: height, weight, body mass index, skeletal muscle mass and body fat percentage, countermovement test (CMJ) and Yo-Yo Intermittent Recovery Test Level I. The main results showed significantly higher values in men than in women in terms of weight, height, skeletal muscle mass, distance covered in the yo-yo test, VO_{2max} , height in CMJ and in flight time. Body fat percentage was higher in women than in men. Centers showed significantly higher height, weight and body fat percentage than other play positions. Guards and forwards covered more meters in the yo-yo test and showed higher VO_{2max} than centers. No significant differences were found between the U16 and U18 categories in any variable. Regression models showed the influence of weight, body fat percentage, skeletal muscle mass and age on VO_{2max} and CMJ. In conclusion, these indicators varied according to the sex and play position of the players. Additionally, this information will be useful for processes of promotion, development and training design of youth basketball in Costa Rica.

Keywords: basketball, assessment, CMJ, Yo-Yo Test, play positions, sex.

RESUMEN

Gutiérrez-Vargas, R., Ugalde-Ramírez, A., Pino-Ortega, J., Trejos-Montoya, J.A., Blanco-Romero, L., Sánchez-Ureña, B., Gutiérrez-Vargas, J.C. y Rojas-Valverde, D. (2022). Perfil antropométrico, aeróbico y de potencia muscular de jugadores juveniles de baloncesto costarricenses. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud**, 20(2), 1-15. El objetivo de este estudio fue describir un perfil antropométrico, aeróbico y de potencia muscular de basquetbolistas juveniles costarricenses según sexo, posiciones de juego y categoría de edad. Se evaluaron 99 jugadores juveniles (43 mujeres y 56 hombres; 18 bases, 51 aleros y 30 pivots; 42 categoría U16 y 57 categoría U18) de ocho equipos diferentes. La experiencia deportiva de los jugadores fue de 6.5 ± 3.1 años. Se realizaron las siguientes evaluaciones: altura, peso, índice de masa corporal, masa de músculo esquelética y porcentaje de grasa, prueba de contramovimiento (CMJ) y prueba de Yo-Yo de Recuperación Intermittente Nivel I. Los principales resultados mostraron valores significativamente mayores en hombres que



en mujeres en peso, talla, masa muscular esquelética, distancia recorrida en la prueba Yo-Yo, VO_{2max} , altura en el CMJ y en el tiempo de vuelo. El porcentaje de grasa fue mayor en mujeres que en hombres. Los jugadores pivots presentaron significativamente mayor estatura, peso corporal y porcentaje de grasa que las otras posiciones de juego. Los bases y los aleros cubrieron más metros en la prueba Yo-Yo y tuvieron mayor VO_{2max} que los pivots. Entre las categorías U16 y U18 no se encontraron diferencias significativas en ninguna variable. Modelos de regresión mostraron la influencia del peso, porcentaje de grasa corporal, masa músculo esquelética y la edad sobre el VO_{2max} y CMJ. Como conclusión, según el sexo y las posiciones de juego de los jugadores, estos indicadores variaron. Además, esta información será útil para procesos de promoción, desarrollo y diseño de entrenamientos de baloncesto juvenil en Costa Rica.

Palabras clave: baloncesto, evaluación, CMJ, Prueba Yo-Yo, posiciones de juego, sexo.

RESUMO

Gutiérrez-Vargas, R., Ugalde-Ramírez, A., Pino-Ortega, J., Trejos-Montoya, J.A., Blanco-Romero, L., Sánchez-Ureña, B., Gutiérrez-Vargas, J.C. e Rojas-Valverde, D. (2022). Perfil antropométrico, aeróbico e de potência muscular de jogadores juvenis de basquete da Costa Rica. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud**, 20(2), 1-15. Este estudo teve como objetivo descrever um perfil antropométrico, aeróbico e de potência muscular de jogadores juvenis de basquete da Costa Rica segundo o sexo, as posições de jogo e a categoria de idade. Foram avaliados 99 jogadores juvenis (43 mulheres e 56 homens; 18 armadores, 51 alas e 30 pivôs; 42 na categoria U16 e 57 na categoria U18) de oito equipes diferentes. A experiência esportiva dos jogadores foi de $6,5 \pm 3,1$ anos. Foram realizadas as seguintes avaliações: altura, peso, índice de massa corporal, massa musculoesquelética e porcentagem de gordura, teste de salto com contramovimento (SCM) e teste de Yo-Yo de Recuperação Intermitente Nível I. Os principais resultados mostraram valores significativamente maiores em homens do que em mulheres com relação ao peso, tamanho, massa muscular esquelética, distância percorrida no teste Yo-Yo, VO_{2max} , altura no SCM e no tempo de voo. A porcentagem de gordura foi maior em mulheres do que em homens. Os jogadores pivôs apresentaram significativamente maior estatura, peso corporal e porcentagem de gordura do que as outras posições de jogo. Os armadores e os alas cobriram mais metros no teste Yo-Yo e tiveram maior VO_{2max} do que os pivôs. Entre as categorias U16 e U18 não foram encontradas diferenças significativas em nenhuma variável. Modelos de regressão mostraram a influência do peso, da porcentagem de gordura corporal, da massa musculoesquelética e da idade no VO_{2max} e SCM. Conclui-se, portanto, que esses indicadores variam segundo o sexo e as posições dos



jogadores. Além disso, essa informação será útil para processos de fomentação, desenvolvimento e desenho de treinamentos de basquete juvenil na Costa Rica.

Palavras-chave: basquete, avaliação, SCM, teste Yo-Yo, posições de jogo, sexo.

INTRODUCTION

Basketball is a cooperation-opposition sport, where two teams of five players compete on a court of 15x28 meters. It is characterized by fast and repeated movements that require both aerobic and anaerobic energy systems to perform the physical activities such as displacements, jumps, sprints, changes of direction, and technical executions and tactical behaviors throughout the game (Ben Abdelkrim et al., [2010](#); Mancha-Triguero et al., [2020](#); Metaxas et al., [2009](#)). Previous studies have described physical activity profiles in males and females. In men, the distance traveled has been reported to be between 68 and 73 m/min and the percentage of distance traveled at a speed greater than 16 km/h is located between 3.1% and 4.1% of total distance traveled (Pino-Ortega et al., [2019](#)). On the other hand, in women's teams, 20.1% of the time of a match the players are stopped (<3.6 km/h), 27.5% walking (3.6–6.5 km/h), 21.5% jogging (6.5–10.2 km/h), 20% running (10.2–14.4 km/h), and 10.7% is spent in sprint running (>14.4 km/h) (Reina et al., [2020](#)).

For optimal performance during games and competitions, it is crucial that basketball players have well-trained qualities such as cardiorespiratory endurance, muscular strength, power, and agility (Gonzalez De Los Reyes et al., [2020](#); Metaxas et al., [2009](#); Zarić et al., [2018](#)). Moreover, it is important because it can help guide training processes (Ziv & Lidor, [2009](#)) and indicate the effectiveness of the different training methods (Vamvakoudis et al., [2007](#)). Likewise, this type of information can also help coaches, scouts, or people responsible of talents selection and identification (Gryko et al., [2018](#); Torres-Unda et al., [2013](#)).

Aerobic and anaerobic capacity can vary depending on factors such as age, sex, and playing positions of the players (Mancha-Triguero et al., [2020](#); Pojskić et al., [2015](#)). Some studies carried out in European young basketball players provide information about the physiological characteristics according to sex (Ziv & Lidor, [2009](#)). Men have higher maximum oxygen consumption (VO_{2max}) than women (Ziv & Lidor, [2009](#)). In Bosnian players (age:19.09 \pm 3.13 years), it was found that aerobic and relative values of anaerobic power are greater in guards and forwards (Pojskić et al., [2015](#)). Regarding muscle power assessed through the CMJ test, a higher jump height is observed in Italian males aged 16.8 \pm 2.0 years (Castagna et al., [2008](#)) compared with Spanish female players of similar age (16.2 \pm 1.2 years) (Fort-Vanmeerhaeghe et al., [2016](#)).

The effect of age on physical capacities has been reported in previous research (Nikolaidis et al., [2015](#)). For example, the distance traveled in the Yo-Yo test differs between three young Italian categories, being higher in U17 players than in U15 and U14 categories (Vernillo et al., [2012](#)). Additionally, the highest jumping values are identified in U16 and U17 male Spanish players compared to U14 and U15 categories (Calleja-González et al., [2018](#)).



The evaluation processes allow knowing and characterizing the anthropometric parameters, mainly in development stages (Gonzalez De Los Reyes et al., [2020](#); Leonardi et al., [2018](#); Matulaitis et al., [2019](#)). Among the characteristics that differentiate basketball players from other athletes and non-athletes are height and body size; whose values tend to be higher in basketball players (Metaxas et al., [2009](#); Tsunawake et al., [2003](#); Vaquera et al., [2015](#)). In U12 - U18 male players of a basketball academy of the Greek first league, it has been reported a body mass index between 17 and 26 Kg/m² (Nikolaidis et al., [2015](#)). In Colombian female basketball players (three categories: infant (U-12), pre-juvenile (U-14), and juvenile (U-16)), the percentage of body fat ranged from 22 to 27% (Gonzalez De Los Reyes et al., [2020](#)). Regarding the percentage of muscle tissue, in European female players it has been reported very similar percentages between playing positions; 41.2%, 42.1% and 41.3% for guards, forward and centers, respectively (Erčulj & Bračič, [2014](#)). In U14 and U15 category players, the predominant type of somatotype is ecto-mesomorphic (Gryko et al., [2018](#); Hadzhiev & Dzimbova, [2020](#)). The players with the highest stature are those who play center positions, followed by the forwards and the guards, who tend to be those who are shorter (Vaquera et al., [2015](#)).

Anthropometric characteristics have been associated with physical performance. In Brazilian U13 and U15 categories, stature was a predictor of performance during the Yo-Yo test (Leonardi et al., [2018](#)). A high body weight negatively affects the physical performance on CMJ and running sprints and endurance tests in U12 and U18 (Nikolaidis et al., [2015](#)). In the studies conducted by Fort-Vanmeerhaeghe et al. ([2016](#)) and Torres-Unda et al. ([2013](#)), the authors found relationships between physical capacities and specific technical actions during games. In U16 and U18 Spanish players, jumping ability, speed, agility, anaerobic power, sprint repeated capacity, and aerobic power were correlated with steals and assists performed per game (Fort-Vanmeerhaeghe et al., [2016](#)), as well as with the number of points achieved throughout a season (Torres-Unda et al., [2013](#)). On the other hand, even anthropometric characteristics and motor ability can explain around 41.3% and 38% of basketball performance in women and men, respectively (Hoare, [2000](#)). In female basketball players aged between 18 and 32 years, anthropometric and physical fitness predicted performance-related parameters (García-Gil et al., [2018](#)).

Given the absence of scientific information on this topic in Costa Rican context, the objective of this study was to describe the anthropometric, aerobic, and muscular power profile of Costa Rican youth basketball players according to sex, playing positions, and age category. In addition, multiple regressions were utilized to know potential anthropometric variables that might influence physical capacities: aerobic endurance and muscular power.

METHODOLOGY

Participants

A total of 99 youth players (43 women and 56 men) from eight Costa Rican clubs in the metropolitan area (GAM) participated in the study. Eighteen were guards, 51 forwards and 30



centers. Also, players were divided according to their chronological age in: U16 category ($n = 42$; age = 15.3 ± 0.6) and U18 category ($n = 57$; age = 17.3 ± 0.4). The average sport experience of the players was 6.5 ± 3.1 years and they trained 3.4 ± 0.1 times per week, and a total of 7.5 ± 3.1 hours per week.

Each player was voluntarily invited to take part in the study, which was ratified with the signing of an informed consent by those of legal age (>18 years) and an assent by underage players (<18 years of age) in conjunction with parental consent. The protocols for this research were approved by the Institutional Review Board of the Universidad Nacional of Costa Rica (CECUNA) through the code 2019-P004.

Instruments

Anthropometrics: A portable stadiometer (SECA, Hamburg, Germany) was used to measure body height to the nearest ± 1 mm. With the stadiometer against a wall, the participant placed himself barefoot, the evaluator confirmed an upright posture and then, considering the Frankfurt plane as a reference, made the measurement.

An InBody 370, model JMW140 (Chungcheongnam-do, South Korea) was used for a bioimpedance analysis with which weight, body mass index (BMI), skeletal muscle mass (SMM), and body fat percentage were determined. The player stepped on the InBody, having removed their shoes and any metal objects; placed their feet on the base electrodes and grabbed the hand electrodes. The participant had to remain in an upright position until the scan was completed.

Muscle power: countermovement jump (CMJ) of Bosco's test was administered on an Axon Jump platform (Bioingeniería Deportiva, San Martín, Argentina), and the Smart Axon 4.02 software was used to obtain the following data: a) jumped height in centimeters and b) flight time in milliseconds. Before applying this test, an explanation and demonstration were provided to the participant. Then, they should start from an upright position with their hands on their hips, perform a squat (90° angle at the knees) and perform an explosive jump without releasing their hands from the hip. Each participant had three attempts with one minute of rest between them. When an incorrect performance was observed, the respective attempt was repeated. The average of the three jumps was considered for analysis.

Aerobic capacity: The Yo-Yo Intermittent Recovery Test Level I was administered. The test consists of performing 20-meter round-trip races at an increasing speed that is directed by an audio recording. There are 10 seconds of active recovery between each race. The test ended if: a) the participant could not reach the first line before the sound (it may just arrive) for the second time, or b) they felt exhausted and unable to continue. Evaluators explained the protocol of the test to players, and they were allowed to take a 3-run test to ensure they understood. This test was applied in groups of eight players simultaneously. The evaluators verified the arrivals to the first line and indicated to the participant when the criterion was not met or when they should withdraw. To estimate the VO_{2max} (ml/kg/min), the following formula was used (Bangsbo, et al., 2008): VO_{2max} (ml/kg/min) = distance (m) \times 0.0084 + 36.4.



Procedure

Firstly, the authors contacted the clubs to invite them to participate in the study. Arrangements were made with the coaching staff to conduct a visit during a training session to explain to the coaches, players, and parents the tests to be carried out, the benefits and possible risks of participating. The informed consent and assent given by the players and parents were read and signed as appropriate.

The tests were administered in the gym used by each club to train, assigning a space for each test. All tests were carried out by evaluators with more than five years of experience, and they were always present at each visit. The order of the tests was as follows: first, each player was asked about his age, playing positions, and years of experience playing basketball. The tests were carried out, starting with the height, then the bioimpedance analysis, the CMJ and ending with the Yo-Yo test. For each test, the results were recorded on a form and then entered in a statistical program for analysis.

Statistical analysis

The Kolmogorov-Smirnov tests were performed to check the normality of the data. An independent samples Student's t-test was utilized for the comparison between men and women, as well as to compare categories U16 and U18. Independent samples one-way ANOVAs were used for the comparison between playing positions (guards, forwards, and centers). When necessary, a Bonferroni post hoc test was applied. To determine the magnitudes of the differences, Cohen's d effect size were calculated for the Student's t-tests (Hopkins et al., [2009](#)), categorized as: 0-0.2 (low), 0.2-0.6 (small), 0.6-1.2 (medium), and >1.2 (large) effect size. For the ANOVAs, the omega squared (ω_p^2) was considered as: > 0.01 (small), > 0.06 (medium), and > 0.14 large (Cohen, [1988](#)). Also, a multiple regression analysis was conducted to determine which anthropometric parameters (height, weight, body mass index, skeletal muscle mass, and body fat percentage) could predict the performance regarding VO_{2max} and CMJ. The method followed to this end was stepwise. Multicollinearity, homoscedasticity, and normality assumptions were checked. All analyzes were performed using SPSS software (Statistic Package for Social Sciences, Chicago, IL) considering a level of significance at $p < .05$.

RESULTS

Table 1 shows differences between men and women in the analyzed variables, except for BMI. Men had a larger body height and weight than women. The percentage of body fat is higher in women, while the skeletal muscle mass is higher in men. In the physical capacities tests, the males showed higher results in the distance traveled in the Yo-Yo test and the VO_{2max} , as well as the height and the flight time of the CMJ.



Table 1

Comparison of the variables between men and women. Data are presented as mean \pm standard deviations

Variables	Women	Men	t	p	d (Cohen)
Height (cm)	166.27 \pm 6.87	175.83 \pm 7.57	-6.480	<.001*	1.31
Weight (kg)	64.06 \pm 12.87	72.29 \pm 12.45	-3.210	.002*	0.65
BMI (kg/m ²)	23.68 \pm 3.35	23.35 \pm 3.54	0.407	.685	0.08
Body Fat (%)	22.44 \pm 8.40	14.93 \pm 6.58	4.833	<.001*	1.00
SMM (kg)	25.90 \pm 3.99	34.77 \pm 5.25	-9.217	<.001*	1.87
Distance (m)	476.28 \pm 203.18	901.43 \pm 339.58	-7.737	<.001*	1.47
VO _{2max} (ml/kg/min)	40.40 \pm 1.71	43.97 \pm 2.85	-7.737	<.001*	1.47
CMJ (cm)	26.53 \pm 4.40	35.21 \pm 5.58	-8.386	<.001*	1.70
FT (ms)	463.48 \pm 38.12	533.85 \pm 44.58	-8.281	<.001*	1.68

Notes. cm= centimeters, kg= kilograms, BMI= body mass index, SMM= skeletal muscle mass, %= percentage, VO_{2max}= maximum oxygen consumption, ml/kg/min= milliliter per kilogram per minute, CMJ= counter movement jump, FT= flight time, ms= millisecond, m= meters.

*Statistically significant difference at $p < .05$. Source: the authors

Table 2 shows the differences between playing positions. No significant differences were observed in SMM, CMJ and FT. The players who play the center positions are taller, have a higher weight and percentage of body fat than the other positions. The guards and forwards covered more distance in the Yo-Yo test, and their VO_{2max} was higher compared to the centers.



Table 2

Comparison of variables between playing positions. Data are presented as mean \pm standard deviations

Variables	Guards	Forwards	Centers	F	p	ω_p^2
Height (cm)	167.78 \pm 8.36 ^c	170.86 \pm 8.67	175.43 \pm 7.61 ^a	5.292	.007*	0.07
Weight (kg)	66.88 \pm 10.95 ^c	63.76 \pm 9.80 ^c	78.22 \pm 14.72 ^{ab}	14.701	<.001*	0.21
BMI (kg/m ²)	24.17 \pm 4.44 ^c	22.03 \pm 3.09	25.58 \pm 3.83 ^a	9.572	<.001*	0.14
Body Fat (%)	19.08 \pm 9.40 ^c	15.04 \pm 6.41	23.01 \pm 8.17 ^a	10.615	<.001*	0.16
SMM (kg)	31.68 \pm 4.30	30.38 \pm 6.23	31.38 \pm 7.90	0.374	.689	0.01
Distance (m)	820.00 \pm 366.93 ^c	771.76 \pm 358.15	561.33 \pm 305.08 ^{ab}	4.508	.013*	0.06
VO _{2max} (ml/kg/min)	43.29 \pm 3.08 ^c	42.88 \pm 3.01	41.11 \pm 2.56 ^{ab}	4.509	.013*	0.06
CMJ (cm)	33.08 \pm 7.47	31.83 \pm 7.04	29.80 \pm 5.23	1.548	.218	0.01
FT (ms)	518.17 \pm 63.03	506.84 \pm 58.32	488.30 \pm 37.98	1.953	.147	0.01

Notes. cm= centimeters, kg= kilograms, BMI= body mass index, SMM= skeletal muscle mass, %= percentage, VO_{2max}= maximum oxygen consumption, ml/kg/min= milliliter per kilogram per minute, CMJ= countermovement jump, FT= flight time, ms= millisecond, m= meters. Source: the authors

*Statistically significant difference at $p < .05$.

^aSignificantly different from guards

^bSignificantly different from forwards

^cSignificantly different from centers

Regarding the comparisons between categories U16 and U18, no significant differences were found in any of the analyzed variables. The data can be seen in Table 3.



Table 3

Comparison of variables according to age categories U16 and U18. Data are presented as mean \pm standard deviations

Variable	U16	U18	t	p	d (Cohen)
Height (cm)	170.19 \pm 8.91	172.78 \pm 8.38	-1.484	.141	0.30
Weight (kg)	67.20 \pm 14.17	69.82 \pm 12.49	-0.971	.334	0.20
BMI (kg/m ²)	23.13 \pm 3.94	23.75 \pm 3.87	-0.784	.435	0.16
Body Fat (%)	17.70 \pm 8.50	18.55 \pm 8.16	-0.499	.619	0.10
SMM (kg)	29.90 \pm 6.27	31.66 \pm 6.56	-1.343	.182	0.27
Distance (m)	642.85 \pm 331.54	771.22 \pm 367.59	-1.789	.077	0.36
VO _{2max} (ml/kg/min)	41.79 \pm 2.78	42.87 \pm 3.08	-1.789	.077	0.36
CMJ (cm)	30.16 \pm 7.35	32.38 \pm 6.01	-1.654	.101	0.34
FT (ms)	494.03 \pm 62.21	510.09 \pm 47.40	-1.459	.148	0.30

Notes. cm= centimeters, kg= kilograms, BMI= body mass index, SMM= skeletal muscle mass, %= percentage, VO_{2max}= maximum oxygen consumption, ml/kg/min= milliliter per kilogram per minute, CMJ= countermovement jump, FT= flight time, ms= millisecond, m= meters. Source: the authors

*Statistically significant difference at $p < 0.05$.

Multiple regressions analyses showed that body fat percentage, skeletal muscle mass, and age, significantly predicted 43% ($R^2 = 0.43$) of the VO_{2max}. Likewise, body weight, skeletal muscle mass, and age predicted 37% ($R^2 = 0.37$) of the performance in the CMJ test. (See Table 4).

Table 4

Summarize the multiple regression models for the physical capacities

Dependent variable	Predictors	β	F	p	R^2
VO _{2max} (ml/kg/min)	Body Fat (%)	-0.183	25.832	<.001	0.43
	SMM (kg)	0.110			
	Age (year)	1.582			
	Constant	32.760			
CMJ (cm)	Body Fat (%)	-0.508	20.975	<.001	0.37
	Weight (kg)	0.188			
	Age (year)	1.155			
	Constant	8.715			

Notes. cm= centimeters, kg= kilograms, SMM= skeletal muscle mass, %= percentage, VO_{2max}= maximum oxygen consumption, ml/kg/min= milliliter per kilogram per minute, CMJ= countermovement jump. Source: the authors.

DISCUSSION

To improve performance in basketball, it is necessary to rely on scientific studies. This is one of the first studies that describes the anthropometric, aerobic, and muscle power profile of Costa Rican youth basketball players according to sex, playing positions and category.

Regarding the anthropometric indicator, average height observed in Costa Rican female players was 166.28 ± 6.87 cm, compared to 175.84 ± 7.57 cm observed in males. In Colombian women players with an average age of 16.7 ± 1.0 years, it has been reported a height of 160.1 ± 0.1 cm (Gonzalez De Los Reyes et al., 2020). In a longitudinal study including Spanish male players of a national academy, the height observed in U14, U15, U16, and U17 categories was 189.2 ± 5.6, 192.0 ± 5.4, 195.6 ± 5.0, and 196.4 ± 4.8 cm, respectively (Calleja-González et al., 2018), which are higher values than those found in the Costa Rican players evaluated in the current study. One aspect influencing the differences in height between athletes from different parts of the world is genetics. Some anthropometric and body composition characteristics of the players are associated with specific characteristics of the population of a specific geographical region. Likewise, genetics influences anthropometric characteristics of the players, and these characteristics can be associated with performance (Leonardi et al., 2018).

Considering the differences found among playing positions in this study, the centers had a higher BMI and body fat percentage compared to the forwards, and guards. The tallest players were the centers. These data agree with what was found in young elite (age: 14.0 ± 0.3) and adult professional (age: 24.4 ± 5.4) male basketball players from Polish clubs (Gryko et al., 2018). Guards players are more mesomorphic compared to the centers, although the centers have a greater fat-free mass, while the forwards tend to be thinner although shorter (Ziv & Lidor, 2009).



Regarding skeletal muscle mass, few studies have reported this variable as such; however, in male players with an average age of 14.6 ± 0.4 years, no differences in fat-free mass were reported between the three playing positions (Erčulj & Bračić, 2014). These differences can be attributed to the specific technical and physical demands of each tactical role. For example, height and arm span ratio are determining criteria for center players (Gryko et al., 2018). Greater stature leads to longer arm lengths, which can facilitate game performance (Calleja-González et al., 2018). In basketball, height has been associated with effectiveness in defensive movements and with the ability to dribble in European players from the U10 to U17 categories (Matulaitis et al., 2019). Similarly, another aspect that can influence these differences, is the level of competition and the talent selection criteria. Players that are categorized as elite typically present a stature higher than non-elite counterparts (Torres-Unda et al., 2013).

Male players have greater height, body weight, and skeletal muscle mass (kg) than female players, while the body fat percentage is higher in women. This agrees with the results of previous studies (Calleja-González et al., 2018; Fort-Vanmeerhaeghe et al., 2016; Gonzalez De Los Reyes et al., 2020; Mancha-Triguero et al., 2020). Differences between sexes can be due to hormonal influence and the biological maturation of the players as well as training experience (Leonardi et al., 2018). Men can develop more muscle mass and grow taller due to the testosterone hormone. In this study, the BMI did not show differences between men and women ($M = 23.35 \pm 3.54$ vs $W = 23.68 \pm 3.35$). These findings are consistent with those reported in previous research (Mancha-Triguero et al., 2020). Male and female BMI was 21.9 and 22.3, respectively in the U16 category, while it was 22.4 for males and 20.5 for females in the U18 category (Mancha-Triguero et al., 2020). European U16 and U18 women reported a body fat percentages of 15.6% and 14.7%, respectively, which is lower (Fort-Vanmeerhaeghe et al., 2016) than the percentage found in Costa Rican players. Differences in body composition indicators between sexes can be associated with eating habits as well as the training regime of athletes (Gonzalez De Los Reyes et al., 2020; Vamvakoudis et al., 2007).

Countermovement jump results were higher in men compared with women. In Greek male U-15 and U-18 players, CMJ test results of 31.8 ± 6.1 cm and 38.6 ± 7.0 cm, respectively were reported (Nikolaidis et al., 2015). In amateur female U16 players from Colombia (Gonzalez De Los Reyes et al., 2020), and in Serbian top female U16 players (Zarić et al., 2018), the CMJ results were between 18 to 25 cm. According to the literature, men show better performance in anaerobic capacities than women (Ziv & Lidor, 2009). A major proportion of muscle mass and less body fat percentage in men can facilitate the development of muscle strength and power (Nikolaidis et al., 2015). In addition, greater stature and leg length can contribute to greater mechanical strength in countermovement tests.

Interestingly, the regression model showed that CMJ performance was predicted by weight, body fat percentage and age. This finding is similar to results reported previously (García-Gil et al., 2018; Nikolaidis et al., 2015; Hadzhiev & Dzimbova, 2020). In elite women basketball players, a greater thickness of the skinfolds was correlated with lower performance in the CMJ, Sprint Test



and agility T-test (García-Gil et al., [2018](#)). Similarly, in 15 young (age: 15.5 ± 1.2 years) basketball players from an Eurobasket team (Blagoevgrad, Bulgaria) moderate to high correlations has been found ($r = 0.53$ to 0.95) between height, body lean mass, body fat mass, soft lean mass, and BMI with parameters of the Wingate test such as peak power, lower power, relative peak power, and anaerobic fatigue percentage (Hadzhiev y Dzimbova, [2020](#)). Additionally, age is a variable that can condition the relationship between body composition and physical performance of the players. A study concluded that BMI differently affected jumping and running performance according to the age groups (Nikolaidis et al., [2015](#)). Another study showed significant differences between categories so that U17 and U18 jumped more cm compared to U15 and U16 athletes (Calleja-González et al., [2018](#)). The influence of age on physical capacities can be associated with physical maturation and development inherent to each age stage (Mancha-Triguero et al., [2020](#)) as well as sport experience and training type (Leonardi et al., [2018](#); Vamvakoudis et al., [2007](#)).

Men covered more distance in the Yo-Yo test and presented a higher VO_{2max} than women. This aligns with what has been reported in the literature. The analyzed youth Costa Rican players covered a distance in the Yo-Yo test within the parameters previously reported for Italian teams sub-elite players of U14, U15, and U16 categories (Vernillo et al., [2012](#)), which was between 729 and 1078 m. Male U16 players reported a VO_{2max} (ml/kg/min) of 60.4 ± 5.1 (Castagna et al., [2008](#)), while female U16 and U18 players had a VO_{2max} (ml/kg/min) of 45.90 ± 2.61 and 46.59 ± 1.81 , respectively (Fort-Vanmeerhaeghe et al., [2016](#)). A review that examined several studies concluded that VO_{2max} in women is between 44 and 54 ml/kg/min and between 50 and 60 ml/kg/min for men (Ziv & Lidor, [2009](#)). In previous studies (Fort-Vanmeerhaeghe et al., [2016](#); Vernillo et al., [2012](#); Ziv & Lidor, [2009](#)); the values of VO_{2max} (ml/kg/min) were higher than the Costa Rican players evaluated in the current study. The differences between Costa Rican women and Spanish women can be due to the player's level. Spanish ones were in an elite category (Fort-Vanmeerhaeghe et al., [2016](#)), while Costa Ricans were no-elite. Also, the frequency of training by week, experience, and fitness level are factors that affect the aerobic capacity (Ziv & Lidor, [2009](#)). Previous research showed that elite players had better results in jump, endurance, speed, and agility tests (Torres-Unda et al., [2013](#)).

Guards and forwards present better results in the Yo-Yo test, likewise, the VO_{2max} was higher compared to the centers. This aligns with results reported previously administering other aerobic tests, like Course-Navette, to youth international males of a Spanish national academy (Calleja González et al., [2018](#)) and administering the 20-m shuttle run test to players of four teams of the Bosnian Premier League (Pojskić et al., [2015](#)). This may be due to the physical demands placed on the tactical functions of these positions. In both, men's (Pino-Ortega et al., [2019](#)) and women's (Reina et al., [2020](#)) U18 teams, the distributors travel a greater total distance per minute and, in turn, perform a greater number of high-intensity routes (Ziv y Lidor, [2009](#)). Also, according to the regression data, a low percentage of body fat can positively influence aerobic capacity. In this sense, guards and forwards were the ones who presented low body fat. An optimal training



process can decrease body fat and increase muscle mass, therefore, VO_{2max} and muscle power can be improved so that players could show a better performance during the matches.

CONCLUSIONS

Sex influenced the anthropometric indicators: height, weight, and skeletal muscle mass, which were higher in men than women. Men presented a lower body fat than women. Similarly, men showed better Yo-Yo test, VO_{2max} , and CMJ test results. Playing positions can condition anthropometric characteristics, aerobic capacity, and muscle power. The tallest and heaviest players were the centers. Guards and forwards had better results in the Yo-Yo test and showed the highest VO_{2max} . Moreover, players with a lower percentage of body fat and higher skeletal muscle mass, body weight, and older players had better aerobic capacity and muscle power.

Practical implications

Considering the differences found between men and women, as well as between playing positions, it is important to consider the specialization in training processes, mainly in training stages.

On the other hand, multiple regression results suggest that it is important to improve the body composition profile of the youth players, due to its impact on aerobic capacity and muscle power. Two physical capacities are crucial for performance in this sport. It is necessary that youth players maintain optimal body weight, decrease body fat and increase muscle mass. These data can guide training strategies focused on improving individual physical performance of the players. Despite not observing differences between U16 and U18 categories, it is recommended to respect the maturation processes of each player, guaranteeing adequate sports development.

The results of the current evaluated players and comparisons with international data are not conclusive, since Costa Rican players present anthropometric characteristics and physical capacities slightly lower, or even higher, about what was reported. It would be necessary to conduct a study with a larger Costa Rican sample, even considering the level of the players as a criterion and whether they play in the national team. This could help establish cutpoints when competing internationally. Additionally, this information is useful for promotion and development of this sport in Costa Rica.

Contributions: Randall Gutiérrez-Vargas (A-B-C-E), José Alexis Ugalde-Ramírez (B-C-D-E), José Pino-Ortega (B-C-D-E), José Andrés Trejos-Montoya (B-C-E), Luis Blanco-Romero (B-C-E), Braulio Sánchez-Ureña (A-B-C-D), Juan Carlos Gutiérrez-Vargas (A-B-E) y Daniel Rojas-Valverde (B-C-D-E)

A-Financiamiento, **B**-Diseño del estudio, **C**-Recolección de datos, **D**-Análisis estadístico e interpretación de resultados, **E**-Preparación del manuscrito.



Contacto de los autores: randall.gutierrez.vargas@una.cr; jose.ugalde.ramirez@una.cr;
josepinoortega@um.es; itrejos@una.cr; luis.blanco.romero@una.cr;
braulio.sanchez.urena@una.cr; juan.gutierrez.vargas@una.cr; drojasv@una.cr

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