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Azahara Fort-Vanmeerhaeghe
*Universitat de Girona; Universitat Ramon Llull*

Alicia Montalvo
*Nicole Wertheim College of Nursing and Health Sciences, Florida International University*, amontal@fiu.edu

Alexander Latinjak
*Universitat de Girona*

Viswanath Unnithan
*Staffordshire University*

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# Physical Characteristics of Elite Adolescent Female Basketball Players and Their Relationship to Match Performance

*by*
*Azahara Fort-Vanmeerhaeghe[1,2], Alicia Montalvo [3], Alexander Latinjak[1], Viswanath Unnithan[4]*

*There were two aims of this study: first, to investigate physical fitness and match performance differences between under-16 (U16) and under-18 (U18) female basketball players, and second, to evaluate the relationship between physical fitness and game-related performances. Twenty-three young, female, elite Spanish basketball players (16.2 $\pm$ 1.2 years) participated in the study. The sample was divided into two groups: U16 and U18 players. The average scores from pre- and post-season physical fitness measurements were used for subsequent analyses. Anthropometric variables were also measured. To evaluate game performance, game-related statistics, including the number of games and minutes played, points, rebounds, assists, steals and blocks per game, were recorded for every competitive match in one season. When anthropometric and physical performance variables were compared between groups, the U18 group demonstrated significantly ($p<0.05$) higher values in upper (+21.2%) and lower (+27.11%) limb strength compared to the U16 group. Furthermore, no significant differences between groups were observed in match performance outcomes. Only two performance variables, steals and assists per game, correlated significantly with jump capacity, speed, agility, anaerobic power, repeated sprint ability and aerobic power ($p \leq 0.005$). These findings can help optimize training programs for young, elite female basketball players.*

**Key words**: *team sports, youth female athletes, game-statistics.*

## Introduction

Optimal performance in basketball is highly complex as it requires a combination of technical and tactical abilities and a high degree of physical fitness (Nidhal et al., 2010; Ziv and Lidor, 2009). In the past decade, the need to further understand the demands of basketball match-play led researchers to study the requirements of high-level players and team performances in several dimensions (Ben Abdelkrim et al., 2007; Gómez et al., 2008; Trninić et al., 2002). In professional sports, the use of performance analysis helps coaches to study team and players' match performances for the purpose of enhancing the training process (Hughes and Franks, 2004; Sarmento et al., 2014). In basketball, one of the most common performance outcomes of interest is the action performed by each player in real match situations, usually indicated by game-related statistics (e.g. points per game, rebounds and assists) (Ibáñez et al., 2009; Ziv et al., 2010). There is limited research that investigated game–related statistics discriminating between winning

[1] - *School of Health and Sport Sciences (EUSES), Universitat de Girona, Salt, Spain.*
[2] - *Blanquerna Faculty of Psychology, Education Sciences and Sport (FPCEE), Universitat Ramon Llull, Barcelona, Spain.*
[3] - *Florida International University, Nicole Wertheim College of Nursing and Health Sciences, Department of Athletic Training, Miami, FL.*
[4] - *Centre for Sport, Health and Exercise Research, Faculty of Health Sciences, Staffordshire University,Stoke-on-Trent, UK.*

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and losing teams in male (Gómez et al., 2008) and female (Gòmez et al., 2009) professional basketball players, and also in U16 (Lorenzo et al., 2010) and U18 male basketball players (Ibanez et al., 2003). The results of these studies vary significantly because game-related statistics of team performance differ depending on the game type, game final score differences, sex, the level of competition, age and the physical fitness characteristics of the team (Lorenzo et al., 2010).

During the season, elite basketball teams follow demanding training and match schedules. Consequently, it is important to evaluate the internal and external load that each player is exposed to as part of the short- and long-term planning for the team. The preparation of these athletes involves developing physical, technical, tactical and psychological attributes (Bompa, 2000; Ziv and Lidor, 2009). It is not known which of these characteristics has the greatest influence on match performance. Furthermore, it is unclear whether the outcomes of physical fitness tests can predict successful performance during the season. There is limited, equivocal data from other team sports such as ice-hockey that demonstrate a correlation between ice hockey game-related statistics and physical fitness capacities including aerobic capacity (Green et al., 2006), as well as strength, power and repeated sprint ability (Burr et al., 2008; Peyer et al., 2011). Conversely, Vescovi et al. (2006) did not find any correlation between physical tests and match performance in professional ice hockey players. Furthermore, McGee and Burkett (2003) and Kuzmits and Adams (2008) found that only some of the physical tests of the National Football League could predict match performance statistics in American football players. It is possible that the physical tests used by some of the authors were not sufficiently sport-specific.

McGill et al. (2012) studied whether specific tests of fitness and movement quality, measured using the Functional Movement Screen, could predict injury resilience and match performance statistics in a team of basketball players (21.4 ◎ 1.6 years) over two seasons. Results showed that better match performance was linked with some physical tests including agility tests and broad jumps. It is important to note that the relationship between match performance and physical fitness may vary according to multiple factors including age, the level of performance, sex and experience. To the best of our knowledge, there is a paucity of research that focuses on characteristics that lead to success in basketball during the formative years, especially in females.

The evaluation of adolescent basketball players is important as it forms the basis for the transition from a promising junior player to an established senior player (Delextrat and Cohen, 2008; Drinkwater et al., 2008). Bompa (2000) describes the post-pubertal age as the initial stage for sports specialization. This age period is also characterized as a time when individuals can tolerate high training loads and competition demands as well as improve their technical and tactical performance levels.

When evaluating the adolescent athletes' performance, the impact of maturation has to be accounted for. The development of stature and body mass in junior players follows a characteristic pattern. The greatest rate of change in body mass occurs approximately 12 months after the growth spurt (peak height velocity) (Croix, 2007; Myer et al., 2013). Consequently, the time surrounding peak weight velocity is thought to be the window of opportunity for strength development (Lloyd and Oliver, 2012).

Consequently, the main objectives of this study were: 1) to investigate physical fitness and match performance differences between under-16 (U16) and under-18 (U18) female basketball players, and 2) to evaluate the relationship between physical fitness and game-related performances.

## Material and Methods

### *Participants*

Twenty-three elite, female, youth basketball players (age: 16.2 ± 1.2 years) were selected for this study. All the participants were part of a Spanish basketball program (Siglo XXI team) aiming to create future professional female basketball players (Joaquim Blume Residence, Catalunya, Spain). Players were eligible for participation in the study if they were 14–18 years old at the beginning of the study (2013-14 season), female, and elite basketball players. The players were divided into a U16 group (players born before 1997) that participated in the first junior Catalan category and a U18 group (players born before 1995) that participated in the second national female basketball league. Most of the players included in the research were part of the Spanish national basketball teams in their respective age groups. Players were excluded if they had an illness or injury that resulted in a loss of practice time for more than 20% of the study period. In addition to a weekend match, routine training sessions occurred 8-10 times per week and lasted approximately 90-120 min each. Before the study started, participants and their parents received detailed written and verbal information about the possible risks and discomforts associated with testing. Written informed consent and assent were obtained from both parents and participants, respectively. The Catalan Sport Council Ethics Committee approved the study.

***Procedures***

To evaluate physical fitness, the mean scores of the physical fitness tests conducted pre- and post-season were used as the representative values. These evaluations were carried out on separate days, over two weeks, with a minimum of 48 hours of rest between assessments. The physical fitness capacities tested were maximal aerobic capacity (day 1), speed and agility (day 2), lower and upper limb explosive strength (day 3), anaerobic capacity (day 4), repeated sprint ability (day 5) and upper and lower limb strength (day 6). To evaluate game-related performance, the average number of games played and the number of minutes played, points, rebounds, assists, steals and blocks per game were calculated for each player during the 2012-13 season.

Prior to every physical performance test, all subjects performed a 10 min neuromuscular warm-up. This consisted of multidirectional movements combined with strength and dynamic stretching exercises and maximal and progressive intensity displacements, including changes of direction, jumps and acceleration/deceleration movements. One week before evaluation, the subjects were familiarized with the testing procedures.

***Measures***

*Biometrics.* Athletes' stature, mass and the body fat percentage were measured following the guidelines of the Spanish Kinanthropometry group (Cruz, JRA, Armesilla, DC, de Lucas, 2009). The body fat percentage was estimated using the Faulkner equation (Faulkner, 1968).

*Aerobic power.* The Yo-Yo intermittent recovery test (Yo-Yo IR1) is a field test used to assess aerobic performance in team-sport players (Bangsbo et al., 2008; Krustrup et al., 2003). The test consists of two 20 m bouts of progressive speed shuttle-running interspersed with 10 s of active recovery and is performed until exhaustion. The test was considered complete when the participant failed to reach the 20 m demarcation lines in-time twice. The total distance covered during the Yo-Yo IR1 was the primary performance measure and the speed attained during the last two sets of 20 m bouts was used to estimate $VO_{2max}$. We used the following equation to calculate the maximum aerobic power:

$VO_{2max}$ (mL/kg/min)= 24.8 + (0.014 * meters covered).

The test was performed on the basketball court. The Yo-Yo IR1 had been shown to have good reliability and validity (Bangsbo et al., 2008; Krustrup et al., 2003).

*Speed.* Maximum sprint speed was assessed by the 3/4 basketball court sprint test (75 feet or 22.86 m). The start and finish lines were clearly marked with cones. Each player completed three sprints with a 3 min rest period between each sprint. The time was recorded with a digital stopwatch to the nearest 0.01 s. Reliability of sprint tests had been reported to be excellent, with ICCs of 0.90 using a hand-held stopwatch (Hetzler et al., 2008). The fastest time of the three sprints was used for further analysis.

*Agility.* The T-test is the optimal test to be used in basketball to evaluate agility as it includes forward, lateral and backward running. Based on the protocol outlined by Pauole et al. (2000), players sprinted from a standing point in a straight line and touched the base of a cone placed 9.14 m away with the right hand. Then, they side shuffled to their left without crossing their feet to another cone placed 4.57 m away and touched its base with their left hand. Next, they shuffled sideways to the right to the third cone placed 9.14 m away and touched the base with the right hand. Finally, they shuffled back to the middle cone, touched the base with the left hand and then ran backwards to the starting line. Two trials were completed and the fastest time was used for further analysis. Time to completion was measured using a digital stopwatch to the nearest 0.01 s. This test had previously demonstrated good reliability (Hetzler et al., 2008; Sassi et al., 2009).

*Lower limb explosive strength.* Three squat jumps (SJ), countermovement squat jumps (CMJ) and Abalakov jumps (ABK) were performed on a contact mat (Chronojump Boscosystem, Barcelona, Spain) (Bosco et al., 1983). Flight time was recorded using Chronojump software to calculate the vertical jump height obtained (De Blas et al., 2012). Every jump was separated by a rest period of 20 s. The highest vertical jump height was used for further analysis.

*Upper limb explosive strength.* We used the overhead medicine ball throw with a 3 kg ball to assess upper body explosive strength during basketball practice (Palao and Valdés, 2013). The players stood at a line with the feet shoulder-width apart and faced the direction in which the ball was to be thrown. The ball was brought back behind the head and then thrown forward vigorously as far as possible. The player was not permitted to step forward over the line before or after the ball was released. Players were allowed three attempts. Throw distance was measured using a measuring tape that was fastened on the floor. The greatest distance thrown was used for further analysis.

*Anaerobic capacity*. We used the line-drill or "suicide" run test to assess the anaerobic capacity (Carvalho et al., 2011). Players were asked to perform four consecutive shuttle sprints of 5.8, 14.0, 22.2, and 28.0 m on a regulation basketball court. Standardised verbal encouragement for an all-out effort was given throughout the test. Two trials separated by 10 min were completed and the fastest time was used for analysis. Time to completion was measured using a digital stopwatch to the nearest 0.01 s. This method had previously demonstrated good reliability (Hetzler et al., 2008; Sassi et al., 2009).

*Repeated sprint ability (RSA).* The ability to sprint repeatedly over duration of a basketball match is an important component in basketball conditioning (McInnes et al., 1995). A basketball-specific repeated sprint ability protocol consisting of 10 shuttle run sprints of 30 m (designed as a 15m out and back course) interspersed with 30 s of passive recovery was conducted (Castagna et al., 2008). Sprint performance during the test was assessed with a photocell beam connected to a computer (Chronojump BoscoSystem, Barcelona, Spain) (De Blas et al., 2012). Subjects were encouraged to decelerate as soon as possible after crossing the finish line and to walk slowly back to the start line to wait for the next sprint. We calculated the mean of the ten sprints and recorded the fastest sprint time. Both were used for further analysis.

*Strength.* Strength was measured using a one-repetition maximum (RM) prediction equation for repetitions to fatigue for the bench and leg press exercises (Technogym, Spain). The participants warmed up with the first and second sets using a low weight. Then, they were instructed to progressively increase the submaximal resistance load (kg) until fatigue. Each set consisted of ten or less maximum repetitions. The test was terminated, when the exercise movement technique deteriorated. There was a minimum of 1 min rest between sets. Strength was determined using the formula from Brzycki (1993): 1RM = kg/ (1.0278 − 0.0278 × repetitions).

*Game-related performance reports*. Measures of performance were obtained from the 2012-13 season. The performance outcomes included the number of games played during the season and an average number of minutes played, points scored, assists, rebounds, steals and blocks per game. Statistical data from the U18 group were obtained from the official scores of the Spanish Basketball Federation. The data for the U16 team were recorded by an expert league basketball coach (Spanish Coaching Federation, Level II). In the U16 group, the number of minutes per game was not recorded and thus, an average could not be calculated.

***Statistical analyses***

Descriptive statistics in the form of means and standard deviations were calculated for each dependent variable for both subgroups (U16 and U18). All the outcomes were assessed with a Shapiro-Wilk's test and data were found to be normally distributed. Independent t-tests were then used to compare dependent variables between the U16 and U18 teams. If no differences were noted, the data were subsequently pooled for analysis with game-related statistics. The relationships between the physical fitness scores and game outcomes were determined by Pearson product-moment correlation coefficients. Differences were considered significant at $p \le 0.05$. All statistical analyses were performed using SPSS software (version 20 for Windows; SPSS Inc., Chicago, IL, USA).

## Results

Three players dropped out of the study due to injury. Table 1 illustrates the remaining subjects' characteristics. Results of independent t-tests indicate that the U16 and U18 groups did not differ, except for age and training experience, as expected.

Players from the U18 group were significantly stronger than players from the U16 group (Table 2 and Figure 1). Under-18 players lifted significantly greater weight on both the bench press, one repetition maximum and the leg press one repetition maximum. No other differences between groups were found (Table 2 and Figures 2 and 3). Additionally, there were no significant differences between groups in any game-related performance variables for which data were available (Table 3). Consequently, the data were aggregated for further analyses.

Only two game-related performance variables correlated significantly with physical fitness test performance (Table 4). Assists per game correlated with: the vertical jump, speed, agility, anaerobic power, repeated sprint ability (mean and best) and aerobic power. Steals per game correlated significantly ($p<0.05$) with: speed, agility, anaerobic power, repeated sprint ability (best) and aerobic power (Table 4).

**Table 1**

*Mean ± standard deviation of age, body mass, stature, training experience and % body fat of the studied sample (N=20)*

| | U16 (n = 9) | U18 (n = 11) | *p* |
|---|---|---|---|
| Age (years) | 15.30 ± 0.50 | 17.00 ± 1.10 | 0.001 |
| Body mass (kg) | 72.30 ± 14.30 | 70.17 ± 8.18 | 0.523 |
| Stature (m) | 1.80 ± 0.08 | 1.82 ± 0.07 | 0.598 |
| Training experience (years) | 5.90 ± 1.70 | 7.00 ± 1.61 | 0.052 |
| Body fat (%) | 15.66 ± 3.31 | 14.77 ± 2.32 | 0.398 |

**Table 2**

*Mean results ± SD of the physical fitness tests and comparisons between U16 and U18 players*

| | U16 | U18 | *p* |
|---|---|---|---|
| Yo-Yo IR1 (mL/min/kg) | 45.90 ± 2.61 | 46.59 ± 1.81 | 0.500 |
| ¾ court sprint (s) | 3.98 ± 0.21 | 3.86 ± 0.17 | 0.149 |
| T-test (s) | 11.04 ± 0.66 | 10.80 ± 0.51 | 0.370 |
| Squat jump (m) | 0.21 ± 0.03 | 0.24 ± 0.02 | 0.400 |
| Countermovement jump (m) | 0.24 ± 0.05 | 0.27 ± 0.03 | 0.131 |
| Abalakov jump (m) | 0.28 ± 0.06 | 0.31 ± 0.03 | 0.218 |
| Ball throw (m) | 6.97 ± 0.41 | 7.28 ± 0.99 | 0.385 |
| Line drill (s) | 31.89 ± 1.51 | 31.80 ± 1.23 | 0.357 |
| RSA mean (s) | 6.45 ± 0.31 | 6.34 ± 0.19 | 0.421 |
| RSA best (s) | 6.28 ± 0.29 | 6.20 ± 0.20 | 0.530 |
| Bench press 1 RM (kg) | 34.04 ± 3.37 | 41.21 ± 34.04 | 0.000 |
| Leg press 1RM (kg) | 143.00 ± 12.96 | 181.78 ± 15.03 | 0.000 |

**Table 3**

*Mean results ± SD of the game-related statistics between U16 and U18 players (N=20)*

| | U16 | U18 | *p* |
|---|---|---|---|
| Games played | 22.00 ± 2.29 | 20.09 ± 2.34 | 0.084 |
| Minutes per game | unavailable | 19.11 ± 8.59 | null |
| Points per game | 5. 77 ± 2.78 | 5.63 ± 4.50 | 0.936 |
| Rebounds per game | 3.41 ± 1.36 | 3.18 ± 2.02 | 0.775 |
| Assists per game | 0.78 ± 0.57 | 0.84 ± 0.65 | 0.835 |
| Steals per game | 0.63 ± 0.49 | 0.84 ± 0.62 | 0.437 |
| Blocks per game | 0.32 ± 0.34 | 0.19 ± 0.19 | 0.285 |

**Table 4**

*Correlation matrix of game-related performance variables and physical fitness tests*

| | | Average per game | | | | | |
|---|---|---|---|---|---|---|---|
| | Games played | Minutes played | Points | Rebounds | Assists | Steals | Blocks |
| Yo-Yo IR1 | 0.123 | 0.238 | 0.155 | -0.318 | 0.661** | 0.564** | -0.112 |
| ¾ sprint | -0.047 | -0.182 | -0.098 | 0.426 | -0.653** | -0.481* | 0.141 |
| T-test | -0.131 | -0.417 | -0.194 | 0.176 | -0.701** | -0.537* | -0.084 |
| SJ | -0.004 | -0.081 | -0.072 | -0.379 | 0.443 | 0.274 | -0.148 |
| CMJ | -0.097 | -0.031 | -0.080 | -0.335 | 0.436 | 0.262 | -0.118 |
| ABK | -0.040 | 0.075 | -0.059 | -0.292 | 0.446* | 0.262 | -0.082 |
| Ball throw | -0.347 | 0.167 | -0.030 | 0.361 | -0.036 | -0.046 | 0.280 |
| Line drill | -0.037 | -0.269 | -0.324 | 0.252 | -0.676** | -0.515* | -0.006 |
| RSA (mean) | -0.174 | -0.154 | 0.234 | 0.339 | -0.620** | 0.416 | 0.039 |
| RSA (best) | -0.175 | -0.239 | -0.272 | 0.302 | -0.643** | -0.476** | 0.012 |
| Bench press 1RM | -0.252 | 0.183 | 0.123 | 0.215 | 0.123 | 0.136 | 0.144 |
| Leg Press 1RM | -0.325 | 0.204 | -0.003 | 0.027 | 0.147 | 0.159 | -0.100 |

* sig. at $p < 0.05$, **sig. at $p < 0.01$

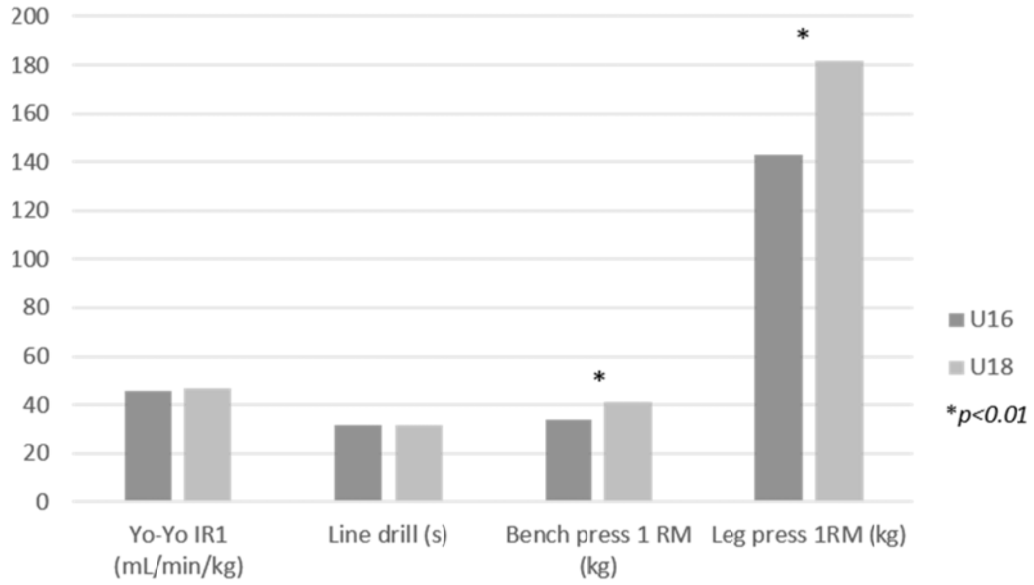


**Figure 1**

*Comparison of physical fitness test scores between U16 and U18 players. All values are means*

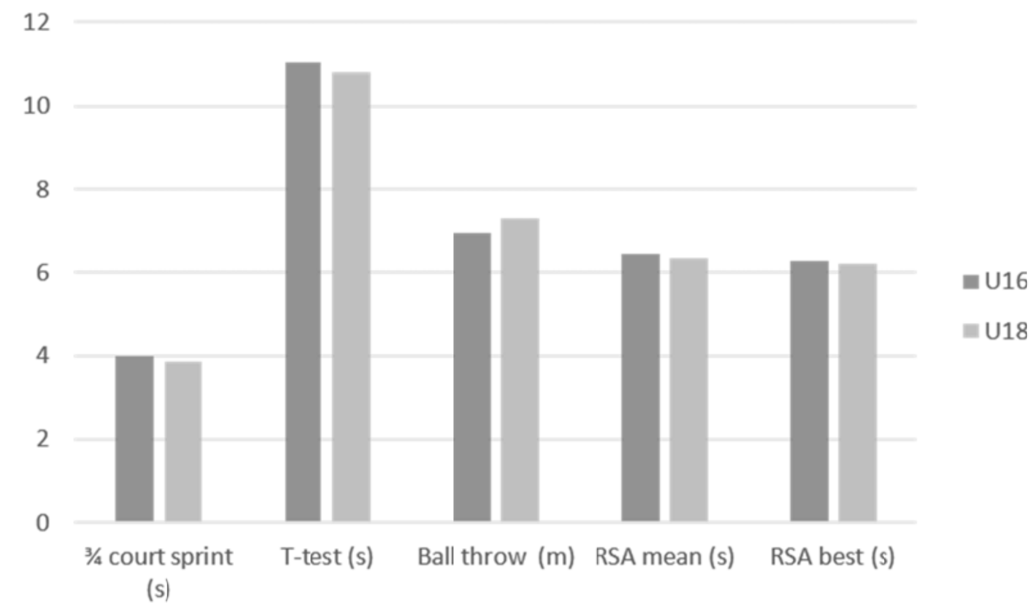


**Figure 2**

*Mean results of physical fitness tests and comparisons between U16 and U18 players*

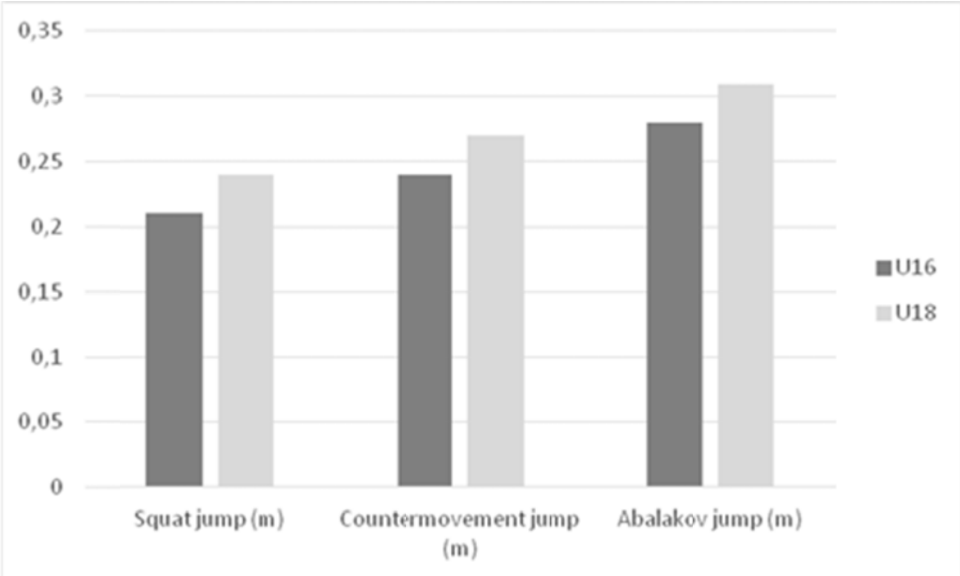


**Figure 3**

*Mean results of physical fitness tests and comparisons between U16 and U18 players*

## Discussion

There were several findings that emerged from this research. When anthropometric and physical performance variables were compared between groups, the U18 group differed significantly from the U16 group only with regard to upper (+21.2% higher than U16) and lower (+27.11% higher than U16) limb strength. Furthermore, no significant differences between groups were observed in match performance outcomes. It is also worth noting that only two performance variables, i.e. steals and assists per game, correlated significantly with jump capacity, speed, agility, anaerobic power, repeated sprint ability and aerobic power.

The first aim of this study was to investigate differences between U16 and U18 players with regard to game-related performance and physical fitness characteristics. Our findings showed that game-related performance did not differ between age groups. These statistically non-significant results may be explained by a small sample size and also the lack of maturity stage measurement in our study. Moreover, there is no comparable data in the extant literature against which to contextualize these findings. The researchers do accept that without maturity status measures, these statements are speculative and have stated this in the manuscript.

For physical fitness characteristics, groups differed significantly only for the strength outcomes (bench press and leg press one repetition maximum). This finding was expected and can be explained by differences in training and chronological age. Under-18 players were at a later stage of pubertal development, which would account for the greater levels of strength measured (Pearson et al., 2006). As previously stated, there exists a time delay (12-14 months approximately) in increasing body mass compared to stature (Philippaerts et al., 2006; Tanner et al., 1976). Consequently, the time surrounding peak weight velocity is thought to be the “window of opportunity” for strength development (Lloyd and Oliver, 2012). Furthermore, there was a statistically significant difference in training age between U16 and U18 groups. Consequently, the older age group had been exposed to greater systematic training and physiological adaptations in strength. Our results are comparable with those of Ingebrigtsen et al. (2013) who conducted a similar study with young elite handball players. They did not find any significant differences in physical characteristics or abilities between the U16 and U18 female national-level handball players (Ingebrigtsen et al., 2013). However, the authors did not measure any strength variables in these female athletes. Methods of existing research on physical fitness in female basketball populations vary greatly, which makes it impractical to compare our findings; however, our subjects achieved similar results in some of the biometric measures and on physical fitness tests previously reported (Erčulj et al., 2010; Hoare, 2000).

The secondary aim of this study was to evaluate the relationship between physical fitness characteristics and game-related performance of elite female adolescent Spanish basketball players. The most significant relationships were noted between assists and steals and aerobic and anaerobic power, as well as speed and agility performance measures. There is a lack of research available investigating the relationship between game-related performance and physical fitness capacity in basketball players. To the best of our knowledge, there is only one similar study in the literature. McGill et al. (2012) showed that the standing broad jump and lane agility time were significantly correlated with some game-related performance measures (e.g. minutes, assists, rebounds) in male basketball players. In addition, with regard to female basketball players, our results agreed somewhat with one previous study that compared game-related statistics between winning and losing teams in women's basketball (Gomez et al., 2006). The results of this study showed that two-point field-goals, defensive rebounds and steals per game were strongly associated with winning teams when compared with losing teams. This finding indicates that it may be of interest to identify and develop physical fitness characteristics that are associated with these game-related statistics in order to improve game performance.

Researchers and coaches are continuously looking for characteristics that will aid in talent development (Vaeyens et al., 2008). Basketball is characterized by high-intensity, intermittent, explosive actions (Ben Abdelkrim et al., 2010; Castagna et al., 2008). Therefore, a variety of skills and physical fitness capacities are required to excel in the sport (Montgomery et al., 2010). Currently, biometric and physical fitness capacities are widely seen as the most important factors that determine basketball performance (Hoare, 2000; Ziv and Lidor, 2009). With regard to game-related performance, some research exists on how these factors relate to winning and losing in men's basketball (Ziv et al., 2010); however, little research has been conducted on game-related performance in female basketball players (Gomez et al., 2006; Gòmez et al., 2009).

There were some limitations associated with this study. It is important to note that specific physical fitness values for predicting on-court statistics have limitations considering the multi-factorial nature of game-related success. Other limitations of our data were the small sample size and the lack of maturity status measurements. The inability to control for maturity status may have masked differences between the two age-groups. Furthermore, the small sample size could have led to large inter-individual variability within each cohort. Another limitation of the study may be the use of hand held stopwatches to test speed and agility. Althouth reliability of sprint tests had been reported to be excellent using this type of equipment (Hetzler et al., 2008), photocells should be used to ensure maximal reliability.

## Conclusions

Our study is one of the first to explore important issues related to age group differences in game-related and physical performance measures in elite adolescent female basketball players. The results demonstrated age group differences for strength characteristics only. Furthermore, there is also evidence from our results to suggest that superior aerobic and anaerobic power, speed, agility and jump capacity are related to some key game-related performance measures.

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**Corresponding author:**

**Azahara Fort Vanmeerhaeghe, Ph.D.**
School of Health and Sport Sciences
c/Francesc Macià, 65, 17190, Salt, Girona, Spain
Phone: +972 405 130
Fax: 972 400 781
E-mail: afortvan@gmail.com