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Differences of muscular performance between professional and young basketball players

Diferencias en el rendimiento muscular entre jugadores de baloncesto profesionales y jóvenes

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Abstract

High performance in a vertical jump, ability to repeat short sprints (RSA) and muscle power are all three most relevant factors for professional basketball players. Still, there is a lack of studies analyzing the differences of these variables between professional and young basketball players. The aim of this research is to study the differences on the vertical jump, the RSA and mechanical power between professional and elite young basketball players. For this, 11 professional ($n = 11$, age = 24.3 ± 5.5 years, height = 200 ± 10.4 cm, weight = 98.4 ± 8.7 kg) and nine elite young basketball players ($n = 9$, age = 15.2 ± 0.4 years, height = 190 ± 6.5 cm, weight = 78.2 ± 5.2 kg) were tested on the Repeated Sprint Test (RAST), Countermovement Jump (CMJ) before and after the RAST, 35 m sprint, and the mechanical power produced in these. The results show non-significance between groups as regards the RAST fatigue index, CMJ height and 35 m sprint time. However, professional players produced significantly more power in these variables than young elite players ($p < 0.05$ - 0.001). These findings may have significant practical relevance on training programs intended for young basketball players.

Key words: Adolescents, fitness, muscle power, sport.

Resumen

El alto rendimiento en el salto vertical, la capacidad de repetir sprints (RSA) y la potencia muscular son 3 de las variables más importantes para los jugadores de baloncesto profesionales. Sin embargo, hay pocos estudios que analicen las diferencias en estas variables entre jugadores jóvenes de alto nivel y sujetos profesionales. El objetivo de este estudio es analizar las diferencias en el salto vertical (CMJ), la RSA y la potencia muscular entre jugadores de baloncesto profesionales y jóvenes talentos. Para ello, un test de RSA, el CMJ antes y después del test de RSA, el sprint de 35 m y la potencia en dichas variables fueron medidas a 11 jugadores de baloncesto profesionales ($n = 11$, edad = 24.3 ± 5.5 años, altura = 200 ± 10.4 cm, peso = 98.4 ± 8.7 kg) y a 9 jugadores jóvenes de élite ($n = 9$, edad = 15.2 ± 0.4 años, altura = 190 ± 6.5 cm, peso = 78.2 ± 5.2 kg). Los resultados muestran que no hay diferencias significativas entre grupos en la fatiga en el test de RSA, la altura alcanzada en el CMJ o el sprint de 35 m. Sin embargo, los jugadores profesionales produjeron significativamente más potencia en estas variables que los jóvenes ($p < 0.05$ - 0.001). Estos hallazgos pueden tener relevancia práctica en el diseño de los programas de entrenamiento para jugadores jóvenes de baloncesto.

Palabras clave: Adolescentes, condición física, potencia muscular, deporte.

Introduction

The ability to repeat short sprints and the vertical jump are most important basketball skills. According to several time-motion studies, these skills are basic in high level basketball games, as they are involved in about a third of all game actions (Abdelkrim, Castagna, Jabri, Battikh, Fazaa, & Ati, 2010; Abdelkrim, El Fazaa, & El Ati, 2007; Narazaki, Berg, Stergiou, & Chen, 2009). So, achieving good performances in these variables is part of any basketball training program from an early age (Abdelkrim et al., 2010; Castagna, Abt, Manzi, Annino, Padua, & D'Ottavio, 2008; Castagna, Manzi, D'Ottavio, Annino, Padua, & Bishop, 2007; Korkmaz & Karahan, 2012; Marzilli, 2008; Ziv & Lidor, 2009). The ability to repeat sprints (RSA) has been much studied in the literature because of its relevance in team sports (Bishop, Girard, & Mendez-Villanueva, 2011; Caprino, Clarke, & Delextrat, 2012; Castagna et al., 2008; Dawson, 2012; Wong, Gar Sun, & Smith, 2012). Numerous tests have been designed to assess the RSA in accordance with the team sport concerned (Bishop et al., 2011; Dawson, 2012; Girard, Mendez-Villanueva, & Bishop, 2011), but the Running-based Anaerobic Sprint Test (RAST) is yet to prevail. It has been validated and proposed as an alternative to the Wingate test for measuring the power output during a race (Adamczyk, 2011; Kaminagakura et al., 2012; Zagatto, Beck, & Gobatto, 2009). Vertical jump is a fundamental basketball skill, in view of the very nature of this sport (Abdelkrim et al., 2010; Korkmaz & Karahan, 2012; Scanlan, Dascombe, Reaburn, & Dalbo, 2012). Improving the vertical jump is instrumental for coaches and players. Many studies on training programs with loads and/or plyometric workouts are aimed at increasing vertical jumping ability in players of all ages and competitive levels (Marzilli, 2008; Santos & Janeira, 2008, 2012).

The development of these skills in young basketball players is instrumental for them to reach the highest competitive level (Baker, 2002). The study of the differences between professional and young elite basketball players is essential to identify the main characteristics of the most competitive athletes. The study should help both to detect talents and design appropriate training programs to reach the desired performance levels. Many authors have analyzed different fitness variables between professional and young elite players (Angius et al., 2012; Baker, 2002; Dauty & Josse, 2004; Faff, Ladyga, & Starczewska-Czapowska, 2000; Gabbett, 2002). For example, it has been observed that professional rugby players have higher levels of maximum strength, short sprint speed, maximal aerobic power and loaded jumps power than young players (Baker, 2002; Gabbett, 2002). However, there is a lack of studies analyzing the differences between professional and young elite basketball players both in vertical jump and repeated sprint performance tests.

This investigation is aimed at studying the possible differences between professional and young elite basketball players in RAST performance, vertical jump, and mechanical power produced in these variables.

Methods

Participants

Eleven professional basketball players (n = 11, age = 24.3 ± 5.5 years, height = 200 ± 10.4 cm, weight = 98.4 ± 8.7 kg) of the Spanish Endesa ACB League, and nine young elite players (n = 9, age = 15.2 ± 0.4 years, height = 190 ± 6.5 cm, weight = 78.2 ± 5.2 kg) from the Spanish National Youth League participated in the study. All the players participated voluntarily and gave prior informed consent.

Study design

An observational study with mean differences was carried out. The participants performed the tests in one day in the following order: (1) Countermovement Jump (CMJ); (2) Repeated Sprint Test (RAST); (3) Countermovement Jump (CMJ). Pre-testing was conducted after the athletes completed a standardized 10-minute warm-up. The study was carried out in the sport facilities of the High Performance Center in Madrid (Spain) on two consecutive mornings (the first one for professional players and the second one for young players), between 10 and 11 a.m. with an ambient temperature of 21 °C. The study was approved by the Ethics Committee of the first author's University.

Measures

The following variables were analyzed: (a) 35 m sprint (S35, in s), (b) power produced in S35 (SP, in W), (c) fatigue index in RAST (FI, in %), (d) mean power output in RAST (MeanPR, in W), (e) maximum power in RAST (MaxPR, in W), (f) CMJ height in pre-RAST (CMJ, in cm), (g) power produced in pre-RAST CMJ (CMJP, in W), and (h) difference in % between height in CMJ pre-RAST and CMJ post-RAST, that is the vertical jump loss (CMJL, in %).

Table 1. Absolute differences between groups, effect size calculations and independent samples t-test results.

Variable	Absolute differences	Hedge's g	t	95 % CI
RAST - FI (%)	0.4	0.05	0.119	[-6.7; 7.7]
MeanPR (W)	+168.1	1.53	3.41	[64.5; 271.6]*
MaxPR (W)	+219.41	1.44	3.197	[75.2; 363.6]*
CMJ (cm)	+1.2	0.24	0.533	[- 3.4; 5.6]
CMJP (W)	+1047.9	2.88	6.415	[704.7; 1391.1]**
CMJL (%)	-4.6	0.93	-2.071	[-9.3; 0.6]
S35 (s)	-0.01	0.04	-0.096	[-0.3; 0.2]
SP (W)	+215.0	1.38	3.073	[68.0; 361.9]*

Abbreviations: CI = confidence interval; RAST = running-based anaerobic sprint test; FI = fatigue index; MeanPR = mean power on the RAST; MaxPR = maximum power on the RAST; CMJ = countermovement jump; CMJP = power on the CMJ; CMJL = CMJ loss or decrease after RAST; S35 = 35 m sprint time; SP = power produced in S35.
*$p < 0.05$. **$p < 0.001$

RAST and vertical jump loss

Pre-testing was conducted after the players completed a standardized 10–minute warm-up, including jogging, running technique, joint mobility and dynamic stretching. The players performed the test in the following order: (a) vertical jump CMJ with arm swing, participants being required to perform 3 trials, and mean height being scored in centimeters (cm), (b) repeated sprint test RAST (Zagatto et al., 2009), consisting of 6 maximum 35 m sprints with 10 seconds recovery between each sprint, and (c) vertical jump CMJ with arm swing with the same protocol as before. The players were told to run each sprint and execute each jump at maximum effort. Finally, we calculated the fatigue index, maximum and mean power on the RAST, and peak power on the CMJ using the following equations (Sayers, Harackiewicz, Harman, Frykman, & Rosenstein, 1999; Zagatto et al., 2009):

- Sprint power (W) = (weight • 1225) / time^3; where "weight" is the weight of the player, expressed in kg, and "time" the seconds it took everyone to run 35 m. The result of this equation is the power in watts for each sprint. The power of each sprint was calculated for each player followed by the peak, mean and minimum values.
- FI (%) = ((maximum power RAST - minimum power RAST) / maximum power RAST)* 100
- PCMJ (W) = (60.7) x (jump height [cm]) + 45.3 x (body mass [kg]) – 2055

Instrumentation

For vertical jump measurements, an infrared Optojump platform was used (Glatthorn, Gouge, Nussbaumer, Stauffacher, Impellizzeri, & Maffiuletti, 2011) (Microgate Corporation, Italy). For RAST test measurements, two pairs of photocells Racetime 2 Light (Microgate Corporation, Italy) based on a laser transmitter and a reflector were used; such technology is much used in electronic timing systems (Earp & Newton, 2012; Glatthorn et al., 2011).

Statistical analyses

To analyze the mean differences between groups, a t-test for independent samples was performed. To estimate the effect size of the differences between groups, we calculated the Hedges' g. The level of significance was set at 0.05. All calculations were performed using the statistical software SPSS Statistics 22 (IBM Corporation, USA).

Results

The independent samples t-test showed no significant differences for any of the variables studied, except for the mean power (+168.01 W, CI = [64.5; 271.6]) and maximum power (+219.43 W, CI = [75.2; 363.6]) of the RAST test and for the CMJP (+1047.9 W, CI = [704.7; 1391.1]) and the SP (+215.0 W, CI = [68.0; 361.9]), where professional team players obtained significantly higher results. The calculation of the g Hedges showed a negligible effect size (FI, CMJ and 35 m sprint), high (CMJL) or very high (MeanPR, MaxPR, PCMJ, SP) effect size. See Table 1 and Figure 1.

Discussion

The results of this study show that the values for professional and young elite basketball players are statistically similar in such essential skills as short sprint speed, ability to repeat sprints or vertical jump. The differences between the two groups are not statistical-

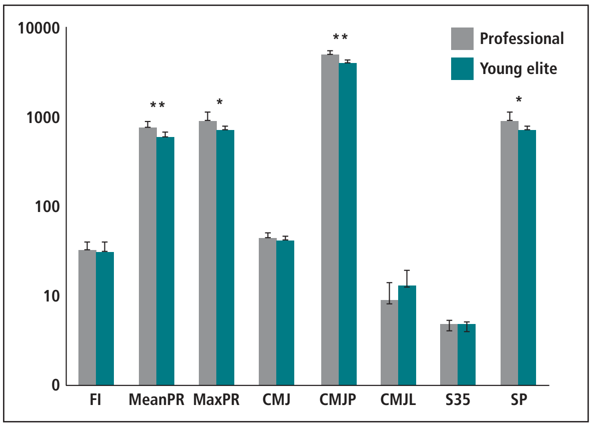

Figure 1. Mean values (with SD bars) of the variables studied in professional and young elite players. A logarithmic scale was used to homogenize the y-axis. *: $p < 0.05$; **: $p < 0.001$.

ly significant; moreover, the effect size analysis shows that there is no trend of superiority in any group for these variables. Thus, professional and young elite players appear to have fully equivalent values in vertical jump, 35 m sprint speed and FI in RAST. Surprisingly, these results differ from the literature where much evidence is found regarding higher performance for adult athletes in muscular power, short sprints and overall physical condition than for young elite athletes (Baker, 2002; Dauty & Josse, 2004; Gabbett, 2002; Sands, McNeal, & Jemni, 2001). However, such studies often compare values of professional athletes with those of amateur athletes (Dauty & Josse, 2004) or the fitness levels of adult athletes with those of young sub-elite athletes (Gabbett, 2002). No study has been found concerning the differences in vertical jump ability and in the short sprint between professional and young elite basketball players.

It would seem that the 15 year old elite players would already have reached the physical performance levels of the professional basketball players. This could be due both to the high intensity of their training (more than 12 hours per week) and early initiation of weight training programs and plyometric exercises (at age 12 or earlier). This fact would support the proposal of many authors on the adequacy of weight training in young subjects (Gorostiaga, Izquierdo, Ruesta, Iribarren, González-Badillo, & Ibáñez, 2004; Ignjatović, Stanković, Marković, & Milanović, 2011; Santos & Janeira, 2008, 2012). Statistically significant differences between professional and young elite players have been found in all variables related to power production. Professional players produced significantly higher mean and maximum power levels with very high effect sizes (g = 1.38 – 2.88) in RAST, 35 m sprint, and vertical jump, compared to the young elite players. This could be explained by another variable (body weight) where both groups differed significantly. Professional players weighed, on average, 20 kg more than the young players, so their power output was much higher although the net physical performance (fatigue index in RAST, time in 35 m sprint and CMJ) was statistically equivalent to that of the young players. Therefore, since the body weight is directly linked to the power produced in the vertical jump and sprints, at the same running speeds and jump heights, the heavier athletes will produce more power to obtain the same results because they have to move a much heavier load (their own weight).

The results of our study would suggest that the training process from young to professional stages seems to be basically intended for maintaining the levels attained at the age of 15, when the body weight and height of the athletes increase significantly, more than for improving performances in RAST, 35 m sprint and vertical jump. In order to optimize the objectives of the training process, it would be interesting to analyze other age ranges to better know in which moment of their training process the young elite players would reach the fitness performances of professional basketball players.

A final finding of this study should be mentioned, that is, the large effect size with regards the difference between young and professional players in vertical jump loss after RAST (g = 0.93). Based on the analysis of superiority probability (Ivarsson, Andersen, Johnson, & Lindwall, 2013), 82% of professional players lost less height in the vertical jump than the young players after the RAST test. In addition, the absolute value of the differences between groups (-4.65% for vertical jump loss) allows us to conclude that the professional players were less affected than the young players by the accumulation of fatigue after repeated sprints in the vertical jump. This difference, though not statistically significant, is important enough to be mentioned, because, inter alia, the ability to repeat vertical jumps after a short sprints series is a relevant factor in basketball (Buchheit, 2010; Buchheit, Spencer, & Ahmaidi, 2010). It would seem that professional players have higher levels of VO_{2max}, anaerobic threshold and running economy than young elite players (Angius et al., 2012; Faff et al., 2000; Millet & Bentley, 2004). One possible reason to account for the differences in vertical jump loss after the RAST test, which is a test with a high anaerobic component (Zagatto et al., 2009), might be that the professional players can perform this test with a lower percentage of their anaerobic threshold; therefore, the post-RAST fatigue index would influence the vertical jump test to a lesser extent. However, as we have not found any study, in the literature, analyzing the relationship between aerobic and anaerobic capacities and vertical jump loss in professional and young basketball players, it would be interesting to study these assumptions in depth.

Conclusions

In summary, the results of this study conclude that (a) the young elite players had the same performance values in the RAST fatigue index, 35 m sprint and CMJ as professional players, and (b) the professional players produced substantially higher power values in these variables because of their greater body weight. For those reasons, training aimed at enhancing muscle strength would seem to be crucial to reach the highest level in basketball. These findings may be of great importance to the training programs of the young basketball players for them to reach professional levels.

REFERENCES

Abdelkrim, N. B., Castagna, C., Jabri, I., Battikh, T., Fazaa, S. E., & Ati, J. E. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *Journal of Strength & Conditioning Research*, *24*(9), 2330-2342.

Abdelkrim, N. B.; El Fazaa, S., & El Ati, J. (2007). Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine*, *41*(2), 69-75.

Adamczyk, J. (2011). The estimation of the rast test usefulness in monitoring the anaerobic capacity of sprinters in athletics. *Polish Journal of Sport & Tourism*, *18*(3), 214-218.

Angius, L., Olla, S., Pinna, M., Mura, R., Marongiu, E., Roberto, S., … Crisafulli, A. (2012). Aerobic and anaerobic capacity of adult and young professional soccer players. *Sport Sciences for Health*, *8*(2-3), 95-100.

Baker, D. (2002). Differences in strength and power among junior-high, senior-high, college-aged, and elite professional rugby league players. *Journal of Strength & Conditioning Research*, *16*(4), 581-585.

Bishop, D., Girard, O., & Mendez-Villanueva, A. (2011). Repeated-sprint ability - Part II. *Sports Medicine*, *41*(9), 741-756.

Buchheit, M. (2010). Performance and physiological responses to repeated-sprint and jump sequences. *European Journal Of Applied Physiology*, *110*(5), 1007-1018.

Buchheit, M.; Spencer, M., & Ahmaidi, S. (2010). Reliability, usefulness, and validity of a repeated sprint and jump ability test. *International Journal of Sports Physiology & Performance*, *5*(1), 3-17.

Caprino, D., Clarke, N. D., & Delextrat, A. (2012). The effect of an official match on repeated sprint ability in junior basketball players. *Journal of Sports Sciences*, *30*(11), 1165-1173.

Castagna, C., Abt, G., Manzi, V., Annino, G., Padua, E., & D'Ottavio, S. (2008). Effect of recovery mode on repeated sprint ability in young basketball players. *Journal of Strength & Conditioning Research*, *22*(3), 923-929.

Castagna, C., Manzi, V., D'Ottavio, S., Annino, G., Padua, E., & Bishop, D. (2007). Relation between maximal aerobic power and the ability to repeat sprints in young basketball players. *Journal of Strength & Conditioning Research*, *21*(4), 1172-1176.

Dauty, M., & Josse, M. P. (2004). Correlations and differences of performance between soccer players, professionals, young players and amateurs, from the 10-meter sprint test and knee isokinetic assessment. *Science & Sports*, *19*(2), 75-79.

Dawson, B. (2012). Repeated-spring ability: Where are we? *International Journal of Sports Physiology & Performance*, *7*(3), 285-289.

Earp, J. E., & Newton, R. U. (2012). Advances in electronic timing systems: considerations for selecting an appropriate timing system. *Journal of Strength & Conditioning Research*, *26*(5), 1245-1248.

Faff, J., Ladyga, M., & Starczewska-Czapowska, J. (2000). Physical fitness of the top Polish male and female tennis players aged from twelve years to the senior category. *Biology of Sport*, *17*(3), 179-192.

Gabbett, T. J. (2002). Physiological characteristics of junior and senior rugby league players. *British Journal of Sports Medicine*, *36*(5), 334-339.

Girard, O., Mendez-Villanueva, A., & Bishop, D. (2011). Repeated-Sprint Ability - Part I: Factors contributing to fatigue. *Sports Medicine*, *41*(8), 673-694.

Glatthorn, J. F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F. M., & Maffiuletti, N. A. (2011). Validity and reliability of optojump photoelectric cells for estimating vertical jump height. *Journal of Strength & Conditioning Research*, *25*(2), 556-560.

Gorostiaga, E. M., Izquierdo, M., Ruesta, M., Iribarren, J., González-Badillo, J. J., & Ibáñez, J. (2004). Strength training effects on physical performance and serum hormones in young soccer players. *European Journal Of Applied Physiology*, *91*(5-6), 698-707.

Ignjatović, A., Stanković, R., Marković, Ž., & Milanović, S. (2011). Effects of resistance training program on dynamic muscle potential in young basketball players. *Research in Kinesiology*, *39*(1), 37-42.

Ivarsson, A., Andersen, M. B., Johnson, U., & Lindwall, M. (2013). To adjust or not adjust: Nonparametric effect sizes, confidence intervals, and real-world meaning. *Psychology of Sport & Exercise*, *14*(1), 97-102.

Kaminagakura, E. I., Zagatto, A. M., Redkva, P. E., Gomes, E. B., Loures, J. P., Kalva-Filho, C. A., …Papoti, M. (2012). Can the running-based anaerobic sprint test be used to predict anaerobic capacity? *Journal of Exercise Physiology Online*, *15*(2), 90-99.

Korkmaz, C., & Karahan, M. (2012). A comparative study on the physical fitness and performance of male basketball players in different divisions. *Journal of Physical Education & Sports Science*, *6*(1), 16-23.

Marzilli, T. S. (2008). The effects of a preseason strength training program on a division II collegiate women's basketball team. *International Journal of Fitness*, *4*(1), 7-14.

Millet, G. P., & Bentley, D. J. (2004). The physiological responses to running after cycling in elite junior and senior triathletes. *International Journal of Sports Medicine*, *25*(3), 191-197.

Narazaki, K., Berg, K., Stergiou, N., & Chen, B. (2009). Physiological demands of competitive basketball. *Scandinavian Journal of Medicine & Science in Sports*, *19*(3), 425-432.

Sands, W. A., McNeal, J. R., & Jemni, M. (2001). Fitness profile comparisons: USA women's junior, senior, and olympic gymnastics team. *Journal of Strength & Conditioning Research*, *15*(3), 398.

Santos, E. J., & Janeira, M. A. (2008). Effects of complex training on explosive strength in adolescent male basketball players. *Journal of Strength & Conditioning Research*, *22*(3), 903-909.

Santos, E. J., & Janeira, M. A. (2012). The effects of resistance training on explosive strength indicators in adolescent basketball players. *Journal of Strength & Conditioning Research*, *26*(10), 2641-2647.

Sayers, S. P., Harackiewicz, D. V., Harman, E. A., Frykman, P. N., & Rosenstein, M. T. (1999). Cross-validation of three jump power equations. *Medicine & Science in Sports & Exercise*, *31*(4), 572-577.

Scanlan, A. T., Dascombe, B. J., Reaburn, P., & Dalbo, V. J. (2012). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science & Medicine in Sport*, *15*(4), 341-347.

Wong, D. P., Gar Sun, C., & Smith, A. W. (2012). Repeated-sprint and change-of-direction abilities in physically active individuals and soccer players: training and testing implications. *Journal of Strength & Conditioning Research*, *26*(9), 2324-2330.

Zagatto, A. M., Beck, W. R., & Gobatto, C. A. (2009). Validity of the running anaerobic sprint test for assesing anaerobic power and predicting short distance performance. *Journal of Strength & Conditioning Research*, *23*(6), 1820-1827.

Ziv, G., & Lidor, R. (2009). Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. *Sports Medicine*, *39*(7), 547-568.