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Research article

POWER CHARACTERISTICS IN SENIOR BASKETBALL PLAYERS - COMPETITIVE-LEVEL DIFFERENCES

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Srdjan Marković[1], Ivan Ćuk[1], Vladan Radonjić[2], Vladimir Momčilović[3]

[1]Singidunum University, Faculty of Physical Education and Sports Management, Belgrade, Serbia
[2]University Union – Nikola Tesla, Faculty of Sport, Belgrade, Serbia
[3]University of Nis, Pedagogical Faculty, Vranje, Serbia

Abstract. *The explosive power of the lower limbs is considered to be one of the most dominant factors in modern basketball. Based on that, we assumed that power characteristics are the factor that distinguishes basketball players of different quality levels. To set qualitative levels, we tested three teams of basketball players (a total of 39 players), each participating in a competition at a different rank, from the highest national (Elite), through second national (sub-elite) to the regional (Amateur) level. Each player completed three parts of testing: jumping tests, sprint tests and isoinertial power tests. Despite the obviously better results of the elite group in the sprint variables compared to the other two groups, statistically significant differences were observed only in tests in which maximal speed (10mF and 20m) was achieved (Elite vs. Amateur, $p<0.05$). In three jumping tests (SJ, CMJa and RJ) we obtained significantly better results in Elite players compared to the other groups (SJ: $p<0.01$; CMJa: Elite vs. Sub-elite $p<0.05$, Elite vs. Amateur $p<0.01$; RJ: $p<0.01$), while in CMJ only a difference between the Elite and Amateur group was observed ($p<0.05$). In isoinertial power tests, the only difference was obtained for knee extensor muscles (Elite vs. Amateur $p<0.05$). In accordance with the results, it can be confirmed that power is a crucial factor in basketball performance and should be a key element in the selection of young basketball players.*

Key words: *Quality Level, Performance, Sprint, Jumps, Selection*

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Corresponding author: Srdjan Marković
Singidunum University, Faculty of Physical Education and Sports Management, Danijelova 32, 11000 Belgrade, Serbia
Phone: +381 11 3 094 094 • E-mail: smarkovic@singidunum.ac.rs

INTRODUCTION

Basketball is an intermittent, high-intensity team sport with complex demands based on individual skills, tactics and strategies, psychological aspects, and physical fitness (Drinkwater, Pyne and McKenna, 2008; Trninic and Dizdar, 2000). Among other factors, fitness plays an essential role in individual and team performance (Bale, 1991, McInnes, Carlson, Jones and McKenna, 1995; Ostojic, Mazic and Dikic, 2006). The basketball game consists of four 10-minute quarters with a 2-minute break between periods and a 15-minute break at halftime. Besides that, there are a lot of game interruptions such as time outs or different violation of rules. As a result, less than 50% of the game is spent in live play. These frequent stoppages allow players to recover between bouts of activity, thus allowing generally the high-intensity of the game (Cormery, Marcil and Bouvard, 2008). In conclusion, the modern game is mainly anaerobic, characterized by polystructural movements, which means that actions during the competition can be realized with a number of motor skills and physical characteristics.

As one of the most complex competitive activities characterized by constantly changed situations, the hierarchy and general structure of abilities for competitive success is a very difficult process. As a result, individuals with different structural abilities and characteristics can be noticed among the best basketball players, which additionally complicate the formation of model characteristics of basketball players. On the other hand, explosive movements such as short sprints, abrupt stops, fast changes of direction, acceleration, different vertical jumps are a crucial part of the basketball game (Zwierko & Lesiakowski, 2007; Erčulj, Dežman, & Vučković, 2004). Converted to motor skills, the ability to produce strength, power, and speed significantly contribute to efficient movement in basketball (Ziv & Lidor, 2009; Abd Al Jabbar, 2015).

The explosive power of the lower limbs, in particular jumping ability, is considered to be a dominant factor in basketball performance (Hoffman, Epstein, Einbinder and Weinstein, 1999). Specifically, a high level of lower-limb explosive power is useful for powerful activities such as accelerations and winning jumps during the game (Hoffman, Epstein, Einbinder and Weinstein, 1999; Hoffman, Tenenbaum, Maresh and Kreamer, 1996). In male professional basketball, players perform approximately 40 jumps of different intensities and more than 100 short sprints (1–2 s) per game, which gives a total of about 150 explosive activities during a game. Additionally, vertical-jump height was related to playing time in elite collegiate basketball, which means that coaches give preference to players with a high level of explosive abilities (Hoffman, Tenenbaum, Maresh and Kreamer, 1996). This is of particular interest to a game outcome because most scoring attempts came from very fast game situations (McInnes, Carlson, Jones and McKenna, 1995).

Previous studies reported that only 5% of sprints performed by basketball players lasted more than 4 seconds, and therefore it seemed that the highest intensity sprints consisted of fast acceleration and deceleration without developing a full speed (Ziv, & Lidor, 2009). Players with well-developed speed characteristics are capable of executing the elements of the modern basketball technique and tactics more efficiently (Harley, Doust and Mills, 2008). Therefore, we can argue that speed should be an important factor in the selection of basketball players (Jakovljević, Karalejić, Ivanović, Štrumbelj and Erčulj, 2017).

Comparisons between players involved in different competitive levels can help identify key physical elements that characterize higher-level players (Le Gall, Carling, Williams and Reilly, 2010; Scanlan, Dascombe and Reaburn, 2011). Studies reported better aerobic and anaerobic physiological adjustment during high-intensity activity in high-level players, compared to lower-level players (Ben Abdelkrim, Chaouachi, Chamari, Chtara and Castagna, 2010; Vernillo, Silvestri and La Torre, 2012; Ferioli et al, 2018). On the other hand, there are conflicting results about strength characteristics and jumping ability in players in different competitive levels (Ben Abdelkrim, Chaouachi, Chamari, Chtara and Castagna, 2010; Ferioli et al, 2018, Koklu, Alemdaroglu, Kocak, Erol and Findikoglu, 2011; Metaxas, Koutlianos, Sendelides and Mandroukas, 2009). Furthermore, the explosive power of the knee extensors did not prove to be sensitive among the qualitative groups. Nevertheless, high-level players possess a better explosive power than lower level players, as shown by the significantly higher ratio of flight and contact time during rebound jumps. This finding suggests that lower-leg explosive power might be considered as a discriminative variable in basketball (Castagna, Chaouachi, Rampinini, Chamari and Impellizzeri, 2009). To our knowledge, not a single study has considered knee flexor explosive power as a variable of interest in basketball. Besides, there is a lack of studies based on isokinetic or isoinertial measurements of strength and power in basketball.

Based on the aforementioned, we concluded that there are conflicting results and conclusions about the physical characteristics of basketball high-level players. Based on previous research, we assumed that power characteristics are the factor that distinguishes basketball players of different competitive levels, and we set an aim to determine which power characteristics differentiate players at these levels.

METHODS

Participants

For this study, 39 basketball players were selected, and consecutively divided into three groups. The first group consisted of 10 players from the teams of the highest Serbian basketball rank (Elite group). The second group consisted of 13 players from the second-best Serbian basketball league (Sub-elite group). Finally, the third group consisted of 16 players from the third-best Serbian basketball league (Amateur group). Their age and anthropometric characteristics are presented in Table 1. None of the participants reported any medical problems or recent injuries. They were informed regarding the potential risks associated with the applied testing protocol. They were also instructed to avoid any unusual strenuous activities throughout the study. All participants gave written informed consent to the experiments, in accordance with the Declaration of Helsinki adopted in 1964 and revised in 2013, and approved by the Institutional Review Board.

Testing procedures

Body height was assessed with a standard Martin anthropometer. Body mass and body fat percentage were assessed using a bioelectric impedance method (In Body 720; USA).

The participants performed maximal 20 m sprint with 10m split time. Therefore, results of the 10m sprint (10m), 10m flying start (10mF), and 20m sprint (20m) were obtained for further analysis. The participants were instructed to start when they are ready and run as fast as possible. Timings were taken using a set of infrared light gates (PAT 02, Uno-Lux NS, Serbia).

Participants were tested on 5 types of vertical jumps. Regarding the squat jump (SJ), they were instructed to hold their hands on their hips and perform a maximum vertical jump from a static starting position where the knee joint angle was fixed at 90°. Concerning the countermovement jump without arm swing (CMJ), the participants were instructed to perform an unconstrained maximum vertical jump from a standing upright position that included the initial counter movement, while keeping their hands on their hips. The countermovement jump with arm swing (CMJa), was performed in the same manner as the CMJ, whereas a natural arm swing was allowed. Regarding the drop jump (DJ), participants were instructed to land from a 30cm box and rebound vertically as quickly as possible with maximal effort just after ground contact with the intent of achieving maximum height. The participants kept their hands on their hips throughout the whole movement to minimize hip extension. Finally, to perform repetitive jumps (RJ) without arm swing, the participants were required to jump as high as possible for 7 consecutive efforts without a pause between jumps, whereas average jump height was chosen as a variable of interest. All jumps were performed on the ergo jump sensor mat (PAT 02, Uno-Lux NS, Serbia), whereas maximal jump height was chosen as a variable of interest.

Bilateral leg extension (LegExt) and leg flexion (LegFlx) tests were performed on the specific machines in the gym to calculate maximal power in watts. Participants were first instructed to perform a leg extension as fast as possible from the knee angle of 110º up to the full extension. Similar to that, leg flexion was performed from the knee angle of 180º up to the full flexion as fast as possible. Length and time to complete both the extension and flexion were measured via linear encoder (FitroDyne, Fitronic, Slovakia) attached to the machines (Jennings, Viljoen, Durandt and Lambert, 2005). Based on the length and the mass of the lifted weight, force, velocity, and consecutively power was calculated in the concentric muscle regimen (Harris, Cronin,Taylor, Jidovtseff and Sheppard, 2010).

Experimental protocol

Each participant completed 3 sessions separated by 5 to 7 days of rest.

The first testing session included anthropometric measurements as well as a verbal explanation of the upcoming tests. In addition, the first session consisted of one repetition maximum (1RM) test, performed separately for bilateral leg extension and bilateral leg flexion. Furthermore, percentages of 1RM were used to determine loadings for the LegExt and LegFlx test.

The second testing session consisted of a sprint test (10m, 10mF, 20m) as the first test, as well as a jump test (SJ, CMJ, CMJa, DJ, and RJ) performed in randomized order except for the RJ (always performed as the final test). All tests were performed 3 times, where the first time was a trial attempt. Furthermore, the best out of two trials was taken for further analysis. Due to the size of the test group (a minimum of 8 players) with participants performing the test one after the other, fatigue was never an issue.

In the third session participants performed only the isoinertial tests. Six maximal contractions of both LegExt and LegFlx (12 maximal contractions in total) were performed. In particular, 2 trials were performed per 3 different loadings (80%, 60% and 40%) for the LegExt, as well as 2 trials per 3 loadings (80%, 60% and 40%) for LegFlx. For both the LegExt and LegFlx tests, maximal obtained power was used for further analysis (regardless of the loading). The rest period between the trials and loadings was 3 minutes.

Finally, note that both the second and third sessions were preceded by a standard warm-up procedure for basketball players (10 min of callisthenic and dynamic stretching).

Statistical analysis

Prior to all statistical tests, descriptive statistics were calculated as mean and standard deviation. Furthermore, the normality distribution of the data was confirmed by Kolmogorov-Smirnov test. In addition, data distribution normality was also verified by the visual inspection of histograms and QQ plots.

One-way ANOVA was applied to test the age and anthropometric differences among the three groups. To assess differences between the three groups in the sprint, jump, and isoinertial tests, one-way ANOVA was applied as well.

In addition, for all ANOVAs, a Bonferroni post-hoc test was performed. The alpha level was set at $p \leq 0.05$. All statistical tests were performed using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA) and SPSS 20 (IBM, Armonk, NY, USA).

3. RESULTS

The participants' age and anthropometric characteristics are depicted in Table 1. No significant differences between the participants were observed regarding age, body height, body mass, and BMI. The only significant difference between the groups was observed in Body fat percentage, where Elite players had a lower body mass percentage than the Amateurs.

Table 1 The participants' age and anthropometric characteristics presented as mean ± standard deviation.

Variables	Elite (n=10)	Sub-elite (n=13)	Amateur (n=16)
Age	22.9 ± 3.1	23.7 ± 3.0	23.2 ± 3.0
Body height (cm)	201.1 ± 6.4	196.1 ± 8.4	196.7 ± 8.5
Body mass (kg)	97.0 ± 12.5	92.6 ± 9.0	95.1 ± 14.0
BMI (kg/m^2)	23.9 ± 2.2	24.0 ± 1.2	24.5 ± 2.4
Body fat (%)	8.8 ± 1.2	11.4 ± 3.6	14.0 ± 5.5*

n = number of participants; BMI = body mass index; * significantly higher from Elite group at p < 0.05.

Regarding the sprint test (Figure 1), the one-way ANOVA performed on 10m did not show a significant main effect (F=2.823; p=0.073). On the other hand, significant main effects were observed when a one-way ANOVA was performed on 10mF (F=4.353; p=0.020) as well as 20m (F=4.004; p=0.027). In particular, the Elite players ran faster than the Amateurs in both the 10mF (p = 0.017) and 20m sprint (p = 0.024).

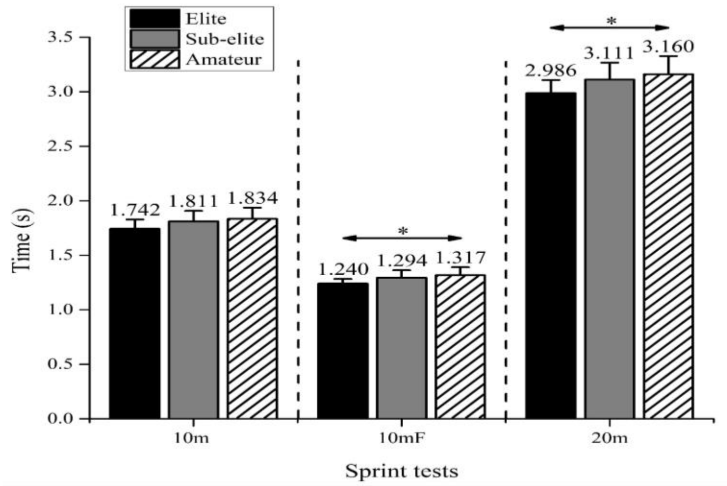

Fig. 1 Results from three participant groups obtained for the sprint test. Data showed as mean ± standard deviation. * - Significant differences at $p < 0.05$.

When the one-way ANOVA was performed on the jump tests (Figure 2), significant main effects were found for SJ (F= 11.849; p< 0.001), CMJ (F= 4.890; p= 0.013), and CMJa (F= 9.289; p= 0.001). Furthermore, Bonferroni post-hoc test results were depicted in Figure 2. Regarding SJ, Elite players jumped higher than both Sub-elite (p = 0.009), and Amateur players (p < 0.001). In the CMJ, Elite players only jumped higher than Amateur players (p = 0.011). Finally, regarding CMJ, Elite players jumped higher than both Sub-elite (p = 0.039) and Amateur players (p < 0.001).

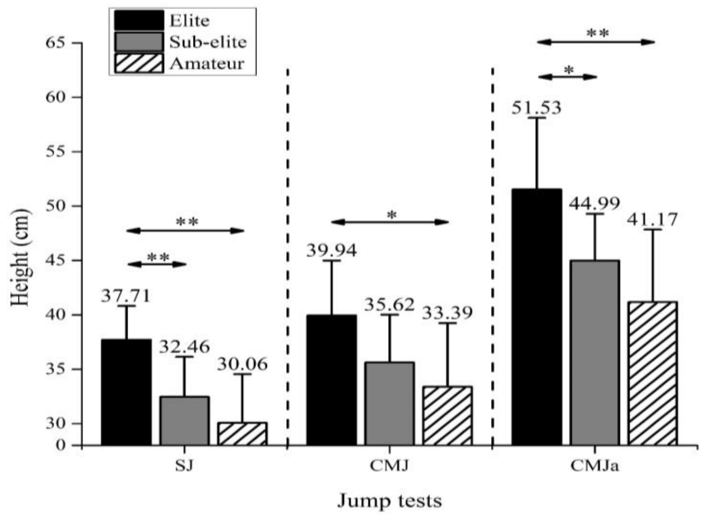

Fig. 2 Results from three participant groups obtained for the three jump tests. Data showed as mean ± standard deviation. * - Significant differences at $p < 0.05$. ** - Significant differences at $p < 0.01$.

Results of the DJ and RJ are depicted in Figure 3. Regarding the DJ, the one-way ANOVA did not show a significant main effect (F= 2.969; p= 0.064). On the other hand, a significant main effect was observed when one-way ANOVA was performed on the RJ (F= 8.82; p= 0.001). Regarding the RJ, Elite players jumped higher than both Sub-elite (p = 0.001) and Amateur players (p < 0.007).

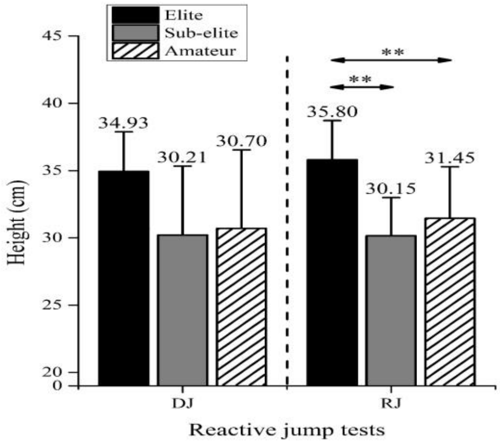

Fig. 3 Results from three participant groups obtained for the two jump tests. Data showed as mean ± standard deviation. ** - Significant differences at p < 0.01.

Finally, the results of the LegExt and LegFlx are depicted in Figure 4. Regarding the LegExt, the one-way ANOVA showed a significant main effect (F= 5.713; p= 0.007). In particular, Elite players achieved greater power than Amateur players (p = 0.005). On the other hand, the one-way ANOVA did not show a significant main effect for LegFlx (F=1.937; p=0.159).

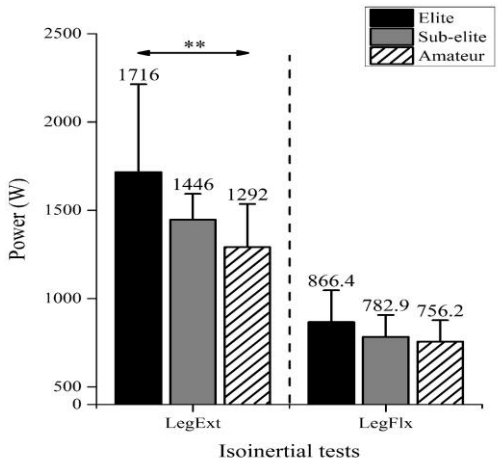

Fig. 4 Results from three participant groups obtained for the two isointertial tests. Data showed as mean ± standard deviation. ** - Significant differences at p < 0.01.

DISCUSSION

Within the present study, we tested various modalities of leg power in basketball players of different qualitative levels. It is important to emphasize that the participants were members of clubs ranked in the top 5 in the league they compete in (Elite – ABA League, Sub-elite – First League of Serbia, and Amateur – Second League of Serbia). Also, we recognized several patterns of movement associated with power. Therefore, three types of power tests were used: Sprint tests, jumping ability tests, and isoinertial tests on the leg extension and leg curl machine. All tests showed differences between the Elite group on the one hand, and the Sub-elite and Amateur group on the other, pointing out the importance of power in basketball performance (Ziv & Lidor, 2009; Hoffman, Epstein, Einbinder and Weinstein, 1999).

Our results suggested that acceleration does not distinguish any competitive level which is in agreement with some earlier research (Koklu, Alemdaroglu, Kocak, Erol and Findikoglu, 2011; Abdelkrim, Chaouachi, Chamari, Chtara and Castagna, 2010). At the same time, it is unexpected because most sprints during the game last 1-2 seconds (Castagna, Chaouachi, Rampinini, Chamari and Impellizzeri, 2009). Also, previous research even recommended using short sprints in fitness programs and testing (Delextrat and Cohen, 2008; Hoare, 2000). Nevertheless, short sprints show a tendency for significance (p=0.073), which requires further research. On the other hand, maximal speed tests (10mF and 20m) seem to have greater influence in the high-level game than acceleration, which is contrary to the previous studies (Koklu, Alemdaroglu, Kocak, Erol and Findikoglu, 2011; Delextrat and Cohen, 2008). This finding can be of great importance, especially when considering the correlation of the 20m sprint test with repeated sprint ability (Pyne, Saunders, Montgomery, Hewitt and Sheehan, 2008). Despite all the data, sprints are an important part of the training and selection of basketball players, given the predominantly anaerobic nature of the game.

Jumping performance is a key element and the most representative explosive movement in basketball, so it is not surprising that in most of the applied jumping tests, there are significant differences between players of different qualitative levels. Most of the studies revealed the same conclusion that the vertical jump capability is related to differences in skill level (Hoare, 2000; Delextrat and Cohen, 2008; Koklu, Alemdaroglu, Kocak, Erol and Findikoglu, 2011; Ferioli et al, 2018). Most of the mentioned studies used just the typical countermovement jump to evaluate jumping performance. In our study, 5 different jumping tests assessing different muscle characteristics were used. Differences observed in 3 jumping tests based on a single jump without the influence of ground contact in jumping performance unequivocally indicate that maximal vertical jump discriminates quality levels of the players (Delextrat and Cohen, 2008; Koklu, Alemdaroglu, Kocak, Erol and Findikoglu, 2011). There is some evidence that these types of jumps highly correlate with repeated sprint ability, which is also an important factor in basketball performance (Stojanovic, Ostojic, Calleja-González, Milosevic and Mikic, 2012).

Both tests assessing explosive muscle power using a combination of eccentric and concentric contraction (shorter ground contact time, longer flight time) could be of great importance in a basketball game, especially in common jump situations after previously failed rebounding, missed shot under the basket, after two-leg stopping (Erčulj, Dežman and Vučković, 2004). In both tests, we can observe better results in the Elite group compared to the other two groups. Despite that fact, we have not been able to determine the significance of the drop jump test (p=0.064). The reasons for that can be found in the relatively low drop height (30cm), which may be insufficient to perform maximum abilities, especially in highly trained basketball players. On the other hand, in the rebound jump, the explosive, reactive character of the muscles comes to the fore, which is in line with previous research, suggested that lower-leg reactive/explosive power might be considered a discriminative variable in the selection of basketball players (Castagna, Chaouachi, Rampinini, Chamari and Impellizzeri, 2009).

Finally, by comparing the players in terms of the power of the knee extensors and flexors, we tried to determine the differences in the characteristics of the muscles that directly participate in performing the aforementioned movements (Rouis et al, 2015; Chaouachi et al, 2009). Furthermore, these muscles are of great interest in terms of injury prevention, especially prevention of anterior cruciate ligament injury (Dervišević and Hadžić, 2012). The observed differences in the power of these muscles characterize not only individuals who play at higher levels of competition, but also the quality and level of training in the teams at each level.

CONCLUSION

The results obtained in this study represent a significant step forward in identifying the most significant elements in basketball performance. Basketball as a game has evolved in recent decades. Rule changes have led to significant changes in the physical abilities of the players. The modern game is full of explosive activities that require faster and stronger players. This paper presented different modalities of power in performance by players of different qualitative levels. Although some expected differences were not observed, there is a clear tendency that all power representations (speed, jump and isoinertial power) presented in this paper are significant in distinguishing player quality.

We must also point out that there are indications that the team position factor could provide additional elements in discriminating qualitative levels. Certainly, at the level of centers and defenders, differences should be sought in different abilities. However, power as an ability, no matter how it is manifested, is a crucial factor in modern basketball and as such should be a key element in the selection of young basketball players.

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RAZLIKE U ISPOLJAVANJU SNAGE SENIORSKIH KOŠARKAŠA U ZAVISNOSTI OD TAKMIČARSKOG NIVOA

Eksplozivna snaga donjih ekstremiteta se smatra jednim od najdominantnijih faktora moderne košarke. Na osnovu toga pretpostavili smo da su karakteristike snage faktor koji razlikuje košarkaše različitog nivoa kvaliteta. Da bismo postavili kvalitativne nivoe, testirali smo tri ekipe košarkaša (ukupno 39 igrača), od kojih svaka učestvuje u takmičenju različitog ranga, od najvišeg nacionalnog (Elitni), preko drugog nacionalnog (Subelitni) do regionalnog (Amaterski) nivoa. Svaki igrač je odradio tri dela testiranja: skokove, sprint testove i izoinercijalne testove snage. Uprkos očigledno boljim rezultatima elitne grupe u sprintu u poređenju sa druge dve grupe, statistički značajne razlike primećene su samo u testovima u kojima je postignuta maksimalna brzina (10mF i 20m) (Elitni naspram Amaterski, $p<0,05$). U tri testa skokova (SJ, CMJa i RJ) uočeni su znatno bolji rezultati kod Elitne grupe igrača u poređenju sa ostalim grupama (SJ: $p<0,01$; CMJa: Elitni naspram Subelitni $p<0,05$, Elitni naspram Amaterski $p<0,01$; RJ: $p<0,01$), dok je u CMJ uočena samo razlika između elitne i amaterske grupe ($p<0,05$). U izoinercijalnim testovima snage dobijena je samo razlika za mišiće ekstenzore kolena (Elitni naspram Amaterski $p<0,05$). U skladu sa rezultatima, može se potvrditi da je snaga kao sposobnost presudni faktor u košarkaškim aktivnostima i da treba da bude ključni element u odabiru mladih košarkaša.

Ključne reči: *nivo kvaliteta, učinak, sprint, skokovi, selekcija*