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Differences in Motor Abilities among Basketball Players in Relation to Biological Maturity

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Abstract

Basketball is a popular team sport with a combination of alternating and high-intensity activities. Physical characteristics related to age and maturity can be quite important for developing the career of a young athlete. The aim of this study was to determine the differences in motor skills among basketball players with regard to their biological maturity. Using the Mirwald equation, the total sample of participants was divided into three groups based on their biological maturity: early-maturing (postPHV), normally-maturing (midPHV), and late-maturing (prePHV). The sample of participants consisted of 51 basketball players (body height 171±12 cm; body weight 63±15.7 kg; BMI 21.3±3.8). Tests of speed (5, 10, 20m sprint), explosive power of the lower extremities (the countermovement jump with arm swing (CMJwas), the countermovement jump (CMJ), and the squat jump (SJ)), and agility (the t-test, zig-zag, and slalom test) were evaluated. The one-factor ANOVA showed a statistically significant difference between groups in the slalom, t-test, and zig-zag test ($p<0.05$). On the sprint tests and tests assessing explosive power no difference was found. We can conclude that this group of participants showed equal performance in motor skills on most tests, regardless of their maturity status. The primary significance of this study is that it shows coaches the importance of understanding their players' biological maturation for optimal selection, suitable training design, and a reduction in the risk of injury.

Keywords: *maturation, youth sport, maximum height gain, growth rate, motor performance*

Introduction

Basketball is a well-known team sport that combines alternating and high-intensity actions (McKeag, 2008). In addition, it is a sport that includes plenty of body contact and an aggressive approach. Although it is a team sport, the individual quality of the athletes can decide the winner of the match in most situations (Mujika et al., 2018). Basketball was primarily invented as a five-on-five game, but then other types were added, such as the three-on-three game that later emerged as an independent sport (Erčulj et al., 2020). Both aerobic and anaerobic movements are involved in the game of basketball, where the predominant anaerobic movements are sprints, changes of direction, and vertical jumps. Precisely because of the manner of play, with plenty of body contact and demanding physical activities, the athlete should always be mentally and physically prepared for every match and training session (Alemdaroğlu, 2012). Strength is known to be an ability that helps us overcome resistance and is important in almost every sport, especially contact sports (Siff, 2000). The dominant type of strength used in the game of basketball is explosive strength, whether it is for shooting at the hoop or taking advantage of the offense. Assessment of strength performance in basketball players is performed through the vertical jump and vertical jump tests (Cole et al., 2020). Vertical jumps are the most frequently repeated motor ability in a basketball game, occurring per

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minute (Stojanović et al., 2018). Therefore, analyzing peak height velocity can be crucial in working with young basketball players when it comes to training (Živković et al., 2022). Basketball players aged 14 have a lower jump height than those aged 16 (Stanković et al., 2022). It is known that athletes who develop per their generation, especially those who reach maturity less progressively, later achieve better results compared to those who developed ahead of time (Chelladurai & Carron, 1983). That is why calculating biological maturity is important during the team selection process and even more important for the development of athletes.

Radiography and the method of sexual characteristics are just some of the methods for calculating biological maturity, but an equally accurate and non-invasive method is the calculation of peak height velocity using anthropometric characteristics (Mirwald et al., 2002). In youth, motor skills are strongly related to growth (Malina et al., 2004). Interestingly, during their growth spurt, male athletes of the same age can differ in biological age (Ramos et al., 2021). Static strength and explosive power develop very quickly after a growth spurt (Te Wierike et al., 2014), and this is the period in which individual players stand out from their peers in terms of quality and talent. One study (Coelho e Silva et al., 2008) showed that height has a positive correlation with passing skills in basketball. Motor and morphological development as well as maturity should be synchronized to stop the stagnation of motor abilities or even injuries (Jakovljević et al., 2016). Physical parameters related to maturity and chronological age can be crucial in the career of a young athlete (Torres-Unda et al., 2013). Some authors have concluded that physical performance is influenced by maturity status, while technical skills are influenced by years of training (Guimarães et al., 2019).

Although the mentioned studies (Torres-Unda et al., 2013; Guimarães et al., 2019) examined the impacts of maturity status in male basketball players aged 11 to 14, no study has looked specifically at male basketball players aged between 14 and 16. Moreover, little is known about the differences in motor abilities related to maturity status in the population of Serbia. Therefore, the aim of this study was to determine the differences in the motor skills of basketball players in relation to biological maturity.

Methods

Participants

Consent for participation was provided by the parents/guardians. All of the participants were fully informed about all the testing procedures, possible risks, and the general purpose of the study before participating. Fifty-one young basketball players aged 12 to 16 volunteered to participate in this study. The total sample of participants was divided into three groups based on their biological maturity: early-maturing (postPHV), normally-maturing (midPHV), and late-maturing (prePHV). The participants were familiar with the testing protocol, were healthy, and had no musculoskeletal disorders. The descriptive statistics of the participants are shown in Table 1.

Table 1. Descriptive statistics of the participants

Groups	Mean±SD	Height (cм)	Body mass (kg)	Chronological Age	Maturity Age@PHV	Body mass index
prePHV	23	162.2±8.5	52.4±8	13±0.6	14.3±0.9	19.9±1.9
midPHV	9	171.9±7.9	64.3±8.5	13.5±0.9	13.6±0.8	21.9±3.1
postPHV	19	182±7.6	75.3±16.5	14.7±0.9	13±0.7	22.7±5.1

Test Procedures

Assessment of anthropometry

Body height was assessed using the Martin anthropometer, model 101 (GPM, Switzerland). The participants stood barefoot on a firm and leveled surface. The standardized command given by the measurer was "Stand still, put your feet together, and look straight ahead". Body mass, the body mass index, fat percentage, and muscle percentage were measured using a portable scale (Vasold et al., 2019) (Omron BF511, Kyoto, Japan). The participants stood on the scales barefoot, in their underwear.

Maturation assessment

Peak height velocity (PHV) was assessed using the method proposed by Mirwald et al. (2002) due to its non-invasive nature and relatively reliable measurement accuracy. The following equation, unique to boys, was used to calculate the number of biological years.

Male offset = −9.236 + ((0.0002708 x (leg length x sitting height)) + (−0.001663 x (age x leg length)) + (0.007216 x (age x sitting height)) + (0.02292 x ((weight/height) x 100). The ranges that determine the maturity of the group of participants are: (prePHV = <-0.5; midPHV = -0.49 – 0.49; postPHV = >0.5).

Physical performance assessment

The warm-up protocol developed by Jeffreys et al. (2007) was used. The coach led the participants through a series of exercises to raise their body temperature before activating the muscles involved and then mobilizing the muscles. The warm-up was completed by using the last phase (potency) as a preparation for more intensive work. All of the participants repeated the test protocol they had learned the day before the test.

The warm-up is shown in Table 2.

Table 2. Warm-up protocol

Aim	Exercise	Sets	Distance (m)
Lifting	knees high, skips, and lateral changes	3	20
Activation	lunges, alternating squats, and "Inchworms"	2	20
Potentiation	Squat jumps, one leg jumps, and pogo jumps	3	20

Speed

Photocells were used to estimate the speed for the 5, 10, and 20-meter sprint (Witty, Microgate, Italy). Each participant repeated the speed test three times, while the pause between attempts was determined by the time it took the participant to return to the starting position by walking at a normal pace. The fastest attempt was included in the statistical analyses. The photocells were placed at hip height, and the participants started the linear sprint at a distance of 5 centimeters from the first gate.

The explosive power of the lower extremities

Photoelectric cells (Optojump, Microgate, Bolzano, Italy) were used to assess the explosive strength of the lower extremities, the reliability and validity of which were already confirmed (Healy et al., 2016). The participant places his hands on his hips. For the starting position of the squat jump, he is in the upright position. The participant needs to perform a quick counter movement - a push-off action. When performing the lowest position, it should be from a semi-squat (knees ~90° and torso/hips in a bent position) as in the case of a squat jump. The jump must be performed as quickly and explosively as possible to ensure the highest jump is made in the shortest time possible. The participants performed three attempts each for the CMJwas, CMJ, and the SJ. The participants performed the jumps voluntarily. The break between each repetition was 30 seconds, while the break between different types of jumps was two minutes. The highest vertical jump value was used for statistical analyses.

Assessment of agility

Agility was assessed using the slalom, t-test, and zig-zag test. The same equipment used for speed assessment was used to assess agility (Witty, Microgate, Italy). In all three tests, the participants voluntarily began the testing procedure. They had three attempts for each test, with one-minute breaks between attempts, while the breaks between tests lasted from 3 to 5 minutes. The slalom test is described as follows: the participant is in a high start with both feet behind the photocells. Six cones are placed 2 m apart. The first one is 1m away from the starting line. Running from the first cone to the second cone, the participant goes around the second cone with the right side of his body and continues running as fast as possible, constantly changing direction from right to left, until he reaches the last cone. At the last cone, the participant makes a 180º turn and continues the slalom run to the finish/start position. In the t-test, three cones are placed in the same plane at a distance of 4.57 meters. The participant runs in a straight line from the gate to the middle cone (9.14m) and touches the top of the cone with his right hand, then laterally moves to the right cone (4.57 m from the middle cone), touches the cone with his right hand, touches the left cone with a lateral movement to the left, touches the middle cone again and then runs back through the gate. The reliability and validity were confirmed in a previous study (Pauole et al., 2000). For the zig- zag test, four cones placed in the corners of a 3-meter by 5-meter rectangle, with another cone placed in the center. If the cones placed in the corners of the rectangle are marked 1 to 4, starting from the longer side, and the central cone is C, the test starts from cone 1 and continues around the cones in the following order C, 2, 3, C, 4, then back to 1. The reliability and validity were confirmed in a previous study (Kutlu & Doğan, 2018).

Statistical data processing

Descriptive statistics were calculated and presented. The Kolmogorov-Smirnov test was used to calculate the data distribution. The one-way ANOVA test and Kruskal-Wallis test were used to determine the differences between groups, and a post hoc analysis was used to determine which group contributed to that difference. The statistical level of significance was set at the level of 0.05, while the statistical processing of the data was done using a statistical package IBM SPSS, version 20 (Inc., Chicago, IL, USA).

Results

Our results provide strong evidence that young basketball players do not differ in motor abilities in most of the variables. The slalom, t-test, and zig-zag test showed a statistically significant (0.013, 0.029, and 0.004 respectively) difference between the groups. The Kolmogorov-Smirnov test showed normal distribution for all the variables excluding the t-test, where the Kruskal-Wallis test was used. The results of the motor abilities are shown in Table 3.

Table 3. P-values of motor ability tests

Tests	p-value
5m (s)	.72
10m (s)	.68
20m (s)	.14
CMJ (cm)	.74
CMJwas (cm)	.83
SJ (cm)	.78
Slalom(s)	.013
T-test (s)	.029
Zig-zag (s)	.004

Legend: 5m - sprint test, 10m - sprint test, 20m - sprint test, CMJ - countermovement jump, CMJwas - countermovement jump with arm swing, SJ - squat jump, T-test - agility test, Slalom test - agility test, Zig-zag - agility test

Table 4. Descriptive statistics for each test group

PHV Groups		Mean	Std. Deviation
prePHV	5m	1.22	.13
	10m	2.06	.17
	20m	3.66	.26
	CMJ (cm)	25.68	4.80
	CMJwas(cm)	31.48	6.02
	SJ (cm)	24.70	4.82
	Slalom(s)	10.19	1.97
	T-test (s)	9.93	2.59
	Zig-Zag(s)	7.87	.83
midPHV	5m	1.15	.11
	10m	1.96	.13
	20m	3.48	.19
	CMJ (cm)	29.15	4.64
	CMJwas(cm)	33.31	6.22
	SJ (cm)	26.91	4.32
	Slalom(s)	10.11	1.35
	T-test (s)	9.36	2.61
	Zig-zag(s)	8.05	.63
postPHV	5m	1.20	.11
	10m	2.01	.15
	20m	3.47	.25
	CMJ (cm)	30.30	7.08
	CMJwas (cm)	36.40	7.60
	SJ (cm)	26.13	5.22
	Slalom(s)	11.49	.98
	T-test (s)	7.48	1.18
	Zig-zag(s)	8.59	.56

Legend: prePHV – late-maturing, midPHV – normally-maturing, postPHV – early-maturing, 5m - sprint test, 10m - sprint test, 20m - sprint test, CMJ - countermovement jump, CMJwas - countermovement jump with arm swing, SJ - squat jump, T-test - agility test, Slalom test - agility test, Zig-zag - agility test

The homogeneity of variance test showed that equal variance was assumed and the Tukey post hoc test was used. In contrast to this, the homogeneity of variance test showed a p value below 0.05 for the t-test; therefore, the Games-Howell test was calculated. The results of the post hoc analysis are shown in Table 5.

The post hoc analysis showed that prePHV and postPHV contribute to statistically different outcomes in the slalom, t-test, and zig-zag test.

Table 5. Post Hoc Analysis for Differences between Maturation Stage

Variable	Sig	PHV
Slalom	0.009	prePHVa
		midPHVab
		postPHVb
T-test	0.001	prePHVa
		midPHVab
		postPHVb
Zig-zag	0.002	prePHVa
		midPHVab
		postPHVb

Legend: prePHV – late-maturing, midPHV – normally-maturing, postPHV – early-maturing different letters denote significant differences

Discussion

The goal of this study was to determine whether there are differences between the motor skills of basketball players with regard to biological maturity. Our results showed significance in the slalom test, t-test, and zig-zag test, while there was no significance in the tests of speed and explosive power of the lower extremities.

Explosive power is considered the most important characteristic of basketball players (Santos & Janeira, 2008). Our results showed no significant difference in vertical jump height between prePHV, midPHV, and postPHV. The results are similar to those of Coelho e Silva et al. (2008b), which showed no statistical difference for the CMJ and SJ in fourteen-year-olds. Also, the results of Ramos et al. (2020) showed that there are no significant differences in the vertical jump performance between participants divided by PHV. Contrary to our findings, Jakovljević et al. (2016) found results showing that normally-maturing young basketball players showed the best CMJ performance, hypothesizing that matched biological and chronological age is the best combination for good motor performance. Another study (Sekine et al., 2019) proved that postPHV basketball players had better jump performance (Cloud jumps) than midPHV and prePHV basketball players. It can be said that the speed and tempo of anaerobic ability improvement depend on biological maturity, not on chronological age.

The change of direction speed is the mechanical basis that supports agility in basketball players (Popowczak et al., 2021). In our findings, a difference was found between the prePHV and postPHV groups on the agility tests, the slalom, t-test, and zig-zag agility test. One study had different results, i.e., there was no difference between groups of basketball players who had different PHV on the agility tests (Arede et al., 2019). In contrast to our results, where prePHV and postPHV had the best results on the agility tests, Jakovljević et al. (2016) found that midPHV basketball players had the best results on agility tests (the t-test, zig-zag test).

During a basketball game, a player's speed ranges from 0 to 8 m/s (Oba & Okuda, 2008). Our results showed that players whose timing of maturation varies did not differ on speed tests (5, 10, and 20m). In contrast, normally-maturing basketball players had the best results on the 20 m sprint (Jakovljević et al., 2016). Another study had different results; specifically, postPHV basketball players were better on the 20m speed test than the midPHV and prePHV groups. Also, Sekine et al. (2019) confirmed that a group of postPHV basketball players had the best results on the 10 and 20m sprints. These results were confirmed by Guimarães et al. (2019), indicating that the early-maturing group was taller and heavier, and had better results not only on speed tests, but also on strength and agility tests. The results of these authors have a logical basis, which is that early maturation leads to the overall development of the body and, therefore, better physical performance on tests of motor abilities (Malina et al., 2015).

The limitation of this study is that it is cross-sectional and that some type of intervention is missing. Also, the participants were exclusively basketball players and it is not possible to generalize these results to other populations. Moreover, the number of participants in each subgroup is small, and this might be a problem with the generalization of the data. Future research should be global, with a focus on the playing position, case study, follow-up method, and a greater understanding of the effect of biological maturity on basketball players' motor ability.

Conclusion

Basketball players aged 12 to 16 showed that groups divided by maturity differ on the slalom, t-test, and zig-zag agility tests, while tests of speed and explosive power of the lower extremities showed similar results. Also, prePHV and postPHV had a significant impact on the differences between groups. The primary significance of this study is that it shows coaches the importance of understanding their players' biological maturation for optimal selection, suitable training design, and a reduction in the risk of injury. The results of this study emphasize the significance of the maturity status effect on youth basketball players' physical performance and technical skill development. In general, our findings show that physical performance is affected by maturity status.

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Conflict of Interest
The author declares that there is no conflict of interest.

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