

ORIGINAL SCIENTIFIC PAPER

Identification of the Main Factors of Physical Development and Sports Preparedness in 12, 14 and 16-Year-Old Bulgarian Girls Basketball Players

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Abstract

The regularities in the dynamics of the physical development of the female organism and the changes that occur in it led to problems in the manifestation of motor qualities at different ages. The study aims to optimize the training process of U12, U14, and U16 basketball players by revealing the factor structure and identifying the main factors of physical development and sports fitness in different age groups. Specialized literature was analyzed to carry out the research, and a test battery for sports-pedagogical testing was used, according to Borukova (2021). 173 female basketball players were studied. The results showed a change in the factor models of physical development and the specific performance with age increasing. The factor components with the most significant weight for the U12 are the anthropometric characteristics, for the U14 are the technical basketball skills, while for the U16, the height is a prerequisite for more outstanding achievements in the maximum vertical jump. The rearrangement of the features in the integral factor structure of the sports preparedness enables the coaches to optimize the training process for the U12, U14, and U16 female basketball players.

Keywords: *physical development, training, basketball, girls*

Introduction

Modern basketball is an extremely spectacular and attractive sport, and the selection of young female basketball players requires not only opting for a large stature but also observing the proper development of physical qualities and an excellent level of technical skills.

Factors structure shows that physical qualities were derived as the first component for U12, for U14 that was the anthropometric data, and technical skills for U16. The trend is to have lower results with each past year. This necessitates the design of a new test battery and an up-to-date normative system to it (Tsarova & Borukova, 2012).

While body height is genetically predetermined, power, speed, and change of direction speed are subject to training adaptation and could be used for the assessment of players' physical potential to overcome the challenges of a basketball

game (Stojanovic et al., 2018; Zaric, Dopsaj, & Markovic, 2018; Mancha-Triguero, García-Rubio, Calleja-González, & Ibáñez, 2019).

For monitoring the functional state of athletes and determining the level of sports training it is necessary to constantly conduct tests with young female players. Timely adjustments in the sports coaching and training process can be done after proper processing and analysis of the results for the achievement of short-term and long-term goals. Depending on the importance of the individual indicators for the sporting achievement, their factor weights are more or less important for the optimization of the training process in a strategic aspect. Evaluation of results with the help of normative tables provides the opportunity for optimization of the training process depending on the momentary level of development of each of the signs of competitive efficiency (Tsarova, 2012;



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Borukova, 2021).

To the greatest extent, the contribution of each of the studied indicators to the sporting achievement of a given individual or group depends on 3-4 main factors (Tsarova & Borukova, 2012).

The contribution of each of the researched indicators to the sports achievement of a particular person or a group of people depends to a great extent on 3-4 major factors (Tsarova & Borukova, 2012).

This is important in selection as well as training evaluation processes. Identification of younger players who have the good physical potential for basketball games reduces the probability of false selection, while early detection of deficits in the main physical abilities indicates that the training could be adjusted and may reduce the risk of unwanted injuries (Greco, Koropanovski, Jakovljevic, & Dopsaj, 2022).

Managing the selection and training process depends on the adequacy of the assessment system in collecting information on an athlete's or a team's training level in order to provide a precise evaluation of the training level (Zatsiorsky & Kraemer, 2008; Ivanovic, Dopsaj, Jakovljevic, & Karalejic, 2019; Belyakova & Gorskaya, 2022). Furthermore, the usability of results obtained by the assessment depends on the specificity and sensitivity of the applied tests. The more specific the test is with regard to sport, the more representation of competitive readiness is valid (Drinkwater, Pyne, & McKenna, 2008; Zaric et al., 2018; Ivanovic et al., 2019).

The available literary sources reveal a lack of specific tests and normative systems for assessment of the physical qualities and specific preparation in the different age categories - U12, U14, and U16 female basketball players.

Tests of a generic nature have more frequently been used for assessing physical fitness in basketball players, e.g., aerobic and anaerobic capacity or jump performance (Drinkwater, Pyne, & McKenna, 2008; Zaric et al., 2018; Mancha-Triguero et al., 2018; Ivanovic et al., 2019; Brini et al., 2020).

Scientific and practical experience of the basketball experts is exceptionally important for achieving high-effective control (Borukova, 2021). With our rich experience in setting up sport-pedagogical tests in basketball for coming up generations, after a questionnaire with basketball coaches in Bulgaria, we have established that the test batteries applied till now make it difficult for the coaches as the tests are numerous and require more than one training session. Analyzing various test batteries from leading basketball schools such as Spanish, Russian, American, Serbian, and Australian, we have established that in additionally to the tests for physical development and physical preparedness, there should exist such, which are most close to the 4 tests presented by AAHPERD (American Alliance for Health, Physical Education, Recreation and Dance), so we apply tests submitted in Bulgaria (Tsarova & Borukova, 2012), tests from a test battery applied in the USA (Popovic, 2007) and those from Serbia (Karalejić & Jakovljević, 1998) with a total duration of 120 minutes. that is why we have combined tests (Popovic, 2007).

Up to now, all coaches of the teams which took part in the sport-pedagogical study with Borukova's (2021) new test battery think that it covers exhaustive information in relation to the physical development, physical preparation, and competitors' level of technical skills. They like the fact that the tests are conducted within one training session only, which makes it easier for them; they wish to go on with current and phase

tests during the present season. The use of the Sigma method allows the development of normative tables by which the status of each sign (indicator) under study can be easily evaluated. That would help the work with coaches to optimize the school-training process (Borukova, 2021).

In view of the listed facts, our personal experience, and observations during tests conducted with young female basketball players, this study aims to determine the hierarchical structure of the anthropometric characteristics, physical preparedness, and technical skills in basketball for each individual age group of girls: up to U12, up to U14 and up to U16 years of age. The highest ranked variables of physical development and specific preparedness for each age group show that these indicators are of best usefulness in predicting the future sports development of female players.

Methods

This research was conducted in the period March 2021 – June 2021.

Participants

The research was done among 173 girls in three age groups: (U12, n-71; U14, n-49; U16, n-53). The sport-pedagogical tests are applied by one and the same researcher or coach of the respective team at terrain conditions within the frame of one training session (120 min). The testing session was carried out during morning hours between 10:00 and 12:00 a.m. The anonymity of the children was guaranteed; each one was listed under a different number, known to the team coach only. Everybody participated voluntarily in the research and has not received money or financial compensation for his/her contribution. Nobody from the participants refused to take part in the study except those injured or not feeling well. Team coaches had the consent of the children's parents to carry out the tests. Physical development data were taken in the medical offices of the sports halls and all female players were barefooted and had their sportswear on. Before tests, players had performed a standardized warm-up, consisting of 5 min jogging, 5 min dynamic stretching, and 5 min of short acceleration-decelerations, gradual building of running velocity, submaximal jumping, and agility exercises. Short instructions, video, and demonstration of the test battery were provided prior the tests. The research was effected within standard conditions – a basketball hall with the necessary equipment: chronometer, measuring apparatuses, cones, and basketball balls. The participants performed the tests twice. Better achievements were taken into mind for the analysis of the results.

Measurements

Table 1 presents Borukova's test battery (2021). The test battery covers 20 indicators containing information about the physical development basic signs, physical preparedness, and basketball technical skills. The indicators are divided into three groups: those for physical development from the 1st to the 7th; for physical preparedness from the 8th to the 14th and for technical skills – from the 15th to the 20th indicator. The tests for physical development and physical preparedness are the standard ones used in sports practice for many years already; indicator No.13 "Shuttle run – 140 m" will be the one described as it is somewhat different from the ones in use so far.

Table1. Description of Borukova's Test Battery (2021)

Nº	Indexes	Measurements	Exact. of measurment	Direction of increase
1.	Height – H(cm)	cm	1.0	+
2.	Weight - W(kg)	kg	0.50	
3.	Body Mass Index – BMI (kg/m ²)	kg/m ²	0.01	
4.	Horizontal extension – HE(cm)	cm	1.00	+
5.	Vertical extension – VE (cm)	cm	1.00	+
6.	Chest measurement – Pause – ChMP (cm)	cm	1.00	+
7.	Chest measurement - respiratory difference – ChMD (cm)	cm	1.00	+
8.	Sprint 20 m - S 20m (s)	s	0.01	-
9.	Squat jump - SJ(cm)	m	0.01	+
10.	Vertical jump - VJ(cm)	cm	1.00	+
11.	Maximum Vertical jump - MVJ (cm)	cm	1.00	+
12.	Flexibility - F(cm)	cm	1.00	+
13.	“Shuttle” run - 140 m, Sr (s)	s	0,01	-
14.	Test for swift-moving - Agility - A(s)	s	0.01	-
15.	Dribble and shooting at high speed – DS(s)	s	0.01	-
16.	Catching and passing, shooting the basket-CPS (s)	s	0.01	-
17.	Shooting – time – Sh(s)	s	0.01	-
18.	Shooting – score - Sh 2(n) for 2points	number	0.01	+
19.	Shooting – score Sh 3(n) for 3 points	number	0.01	+
20.	Free throw- FT(%)	%	0.01	+

The technical skills tests are new for the Bulgarian coaches and competitors and for better clearness and perception of the information, they should be described. The lengths done on the court for indicators: №15 Dribble and shooting at high

speed – DS(s) (Figure 1) and № 16 Catching and passing, shooting the basket-CPS (s) (Figure 2) depend on the age of the girls. Girls aged U12 do two lengths, U14 - four lengths, and U16 - six lengths.

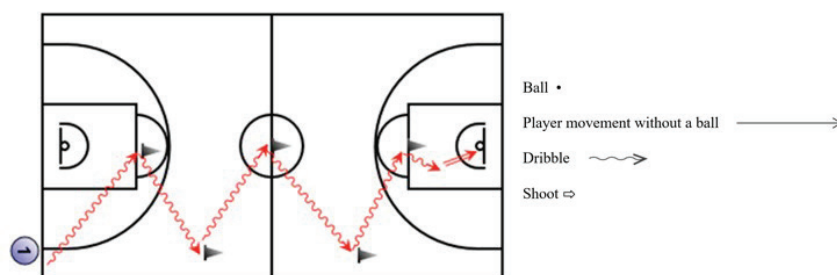


FIGURE 1. Dribble, change of direction at high speed, and shooting while moving

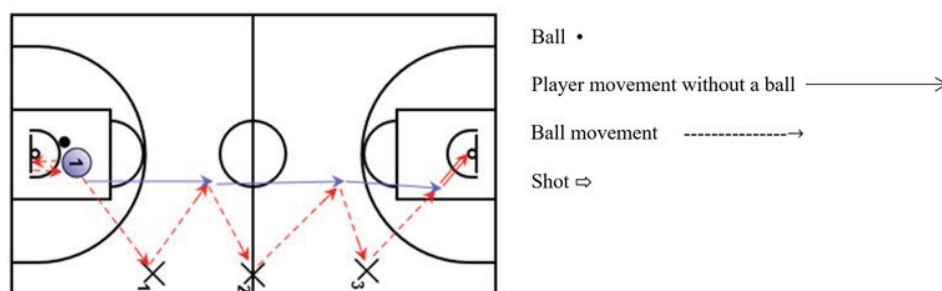


FIGURE 2. Catching, passing on while moving, and shooting while moving

When executing indicator №17 Shooting – time – Sh(s); №18 Shooting – score - Sh 2(n) for two points and №19 Shooting – score Sh 3(n) for three points, the player shoots for

one minute without a passer Sh(s), U12 make ten 2-pointers, while U14 and U16 make five 2-pointers and five 3-pointers (Figure 3).

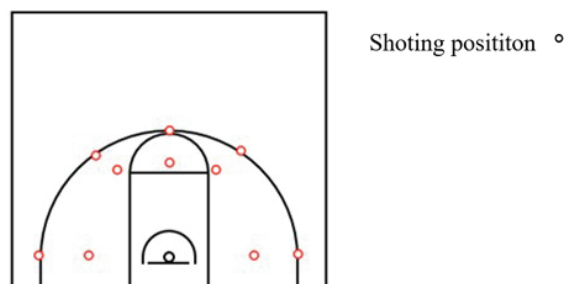


FIGURE 3. Shooting into the basket for one minute from five positions for three points and five positions for two points

For the realization of the purpose and tasks set for the study, the following methods of research were applied: a survey study of the specific literature and sport-pedagogical testing.

Statistics

All statistical operations were carried out by applying the Microsoft® Office Excel 2010 and mathematical-statistical processing with SPSS for Windows, Release 23. depending on the tasks of the research the following statistical method was applied: variation analysis, ANOVA test ($F_{critical}=3.34$), and

Factor analysis and Index method. To achieve more effective control, 50 rate normative system will be developed for the test battery while the normative tables shall be presented respectively by sex and age; for girls up to U12, U14, and up to U16, and for boys up to U12, U14 and U16 (Borukova, 2021).

Results

Results for the descriptive statistics (Mean and Standard deviation) of the observed characteristics with regard to different ages are shown in Table 2.

Table 2. Descriptive Statistics of The Observed Characteristics with Regard to Different Age Groups

№	Indicators	U12	U14	U16
		Mean ± SD	Mean ± SD	Mean ± SD
1.	Height	1.56 ± 0.079	1.66 ± 0.062	1.68 ± 0.068
2.	Weight	45.88 ± 9.245	59.62 ± 11.340	62.82 ± 9.129
3.	Body Mass Index	18.02 ± 4.507	21.46 ± 3.123	22.26 ± 3.143
4.	Horizontal extension	1.55 ± 0.083	1.66 ± 0.064	1.69 ± 0.072
5.	Vertical extension	2.02 ± 0.103	2.14 ± 0.082	2.16 ± 0.093
6.	Chest measurement – Pause	78.23 ± 7.690	86.18 ± 6.369	87.86 ± 5.396
7.	Chest measurement - respiratory difference	6.46 ± 1.468	7.38 ± 1.184	7.52 ± 1.259
8.	Sprint 20 m	3.40 ± 0.332	3.82 ± 0.633	3.78 ± 0.189
9.	Squat jump	1.65 ± 0.202	1.76 ± 0.164	1.80 ± 0.221
10.	Vertical jump	29.41 ± 6.303	32.41 ± 5.377	36.78 ± 6.034
11.	Maximal Vertical jump	33.00 ± 10.00	38.00 ± 6.600	44.97 ± 7.108
12.	Flexibility	100.64 ± 6.703	105.89 ± 7.128	109.23 ± 5.714
13.	“Shuttle” run - 140 m,	34.43 ± 3.113	33.76 ± 1.231	32.68 ± 1.938
14.	Test for swift-moving - Agility	19.65 ± 1.865	18.06 ± 1.154	17.06 ± 0.960
15.	Dribble and shooting at high speed	28.47 ± 4.391	63.94 ± 8.642	83.24 ± 6.457
16.	Catching and passing, shooting the basket	17.87 ± 3.155	30.53 ± 3.116	43.06 ± 2.798
17.	Shooting – time	53.02 ± 5.146	62.96 ± 4.344	63.99 ± 8.881
18.	Shooting – score for 2 points	2.92 ± 2.003	1.10 ± 1.122	1.81 ± 1.302
19.	Shooting – score for 3 points	-	0.76 ± 0.879	1.23 ± 1.103
20.	Free throw (%)	44.79 ± 17.309	39.18 ± 29.780	50.57 ± 24.762

Anthropometry established dynamics in the age development of girls of U12, U14, and U16. For all indicators, the greatest increase is observed in the age between 12 and 14. At H (cm) difference is the biggest of almost 10 cm, respectively at HE (cm) and VE (cm) we also have +12 cm and this also affects the change of W(kg) U12 - 45.88 ± 9.24 and U14 - 59.62 ± 11.340 and of BMI (kg/m²) where values of the areas

of the normal level of obesity for this age (WHO, 2022) are increased. Higher values are also observed with ChMP (cm), where for U12 - 78.23 ± 7.690 cm and for U14 - 86.18 ± 6.369 cm, the difference in chest measurement ChMD (cm) is increased by nearly 1 cm. In the analysis of Table 2, we see that the dynamics of anthropometry values between U14 and U16 are small. ANOVA test was applied for the comparison of dis-

persion between groups only. With $F_{\text{tabl}}=3.34$, the high values of F indicate the strong effect of the age factor on the development of basic anthropometric signs in girls.

Physical indicators of preparedness also show a dynamic development within the age of 12 to 14 where average values register the biggest differences. Smooth development for all three age groups was registered in the high jump VJ (cm), the maximum bounce MVJ (cm), and the flexibility F (cm). Indicators also change positively for agility $A(s)$, where for U12 - $19.65 \pm 1.865s$, for U14 - $18.06 \pm 1.154s$, and for U16 - $17.06 \pm 0.960s$, the differ-

ence is 1-1.5s and SD decreases with an increase of age. Speed endurance $Sr(s)$ - 140 m registers the best improvement between U14 - $33.76 \pm 1.231s$ and U16 - $32.68 \pm 1.938s$.

Regarding dribble and field shooting technical skills, $DS(s)$ indicators as well as field passing and catching CPS (s) cannot be compared as field lengths performed during the test are different for each age group. In the case of shooting without assistance for 1 minute $Sh(s)$ (Table 2), it is obvious that U12 registers the best results for shooting time $Sh(s)$, ($53.02 \pm 5.146s$) as well as number of registered baskets ($2.92 \pm 2.003n$), but

Table 3. Factor Analysis Structure Matrix for Each Age Group

Factor	U12		U14		U16	
	Variables	Value	Variables	Value	Variables	Value
1st Factor	Vertical extension	0.911	Dribble and shooting at high speed	0.951	Vertical extension	0.979
	Horizontal extension	0.903	Horizontal extension	0.941	Height	0.954
	Height	0.883	Shooting – time	0.925	Horizontal extension	0.937
	Weight	0.775	Free throw	0.922	Maximal Vertical jump	0.826
	Chest measurement – Pause	0.690	Vertical jump	0.778		
	Maximal Vertical jump	0.631	Shooting – score for 2points	0.743		
2nd Factor			Shooting – score for 3 points	0.716		
	Sprint 20 m	0.76	BMI	0.955	Shooting – score for 3 points	0.810
	Squat jump	-0.755	Weight	0.879	Shooting – score for 2points	0.777
	“Shuttle” run - 140 m	0.723	Chest measurement – Pause	0.821		
	Vertical jump	-0.614				
	Agility	0.590				
3rd Factor	BMI	0.561				
	Dribble and shooting at high speed	0.873	Vertical extension	0.913	Weight	0.923
	Catching and passing, shooting the basket	0.797	Height	0.899	BMI	0.905
4th Factor					Chest measurement – Pause	0.876
	Shooting – score for 2points	0.955	Agility	-0.884	Shooting – time	0.726
	Free throw	0.504	Squat jump	0.691	Free throw	0.703
5th Factor			Chest measurement - respiratory	0.648	“Shuttle” run - 140 m	0.689
	Shooting – time	-0.657	Catching and passing, shooting the basket	0.774	Dribble and shooting at high speed	0.958
			Maximal Vertical jump	0.842	Catching and passing, shooting the basket	0.956
6th Factor	Flexibility	-0.635	“Shuttle” run - 140 m	-0.838		
	Chest measurement - respiratory	0.541				
7th Factor			Sprint 20 m	-0.777	Squat jump	-0.713
			Flexibility	0.626	Vertical jump	-0.689
8th Factor					Agility	0.670
					Sprint 20 m	0.590
					Flexibility	0.852
					Chest measurement - respiratory	-0.544

they shoot for 2 points only. U16 registered most of the total shootings for 2 and for 3 points and they have the highest percentage of registered free throws ($50.57 \pm 24.762\%$). In order to have a high percentage of registered free throws proper technique and many shootings are needed.

With the help of the ANOVA test, it was established that the age factor has a moderate influence on the execution and realization of the free throws ($F=5.01$).

Perhaps distinguish between proficient and non-proficient free throw shooters in 94% of the cases, small changes in their magnitudes may lead to unsuccessful free throw shooting outcomes (Dimitrije, Fry, John, & Michael, 2021).

For all age groups, the factor analysis extracted different numbers of significant factors (Table 3), which cumulatively explained 73.02%, 79.48%, and 82.40% of the variance in U12, U14, and U16. Extracted factor components increase progressively with age, as well as the explained dispersion, which was highest with U16 of 82.40%.

Table 3 shows the structure matrix with the variable saturation for each age group. Measured physical characteristics provide a similar factor structure for each age group. Anthropometric indicators register the greatest availability in the first factor of U12. With U14 in the first factor are the indicators of technical skills in basketball and the vertical jump. With U16 anthropometric indicators that define a bigger maximal vertical jump are included in the first factor. For girls of U12, factor components are 6, the second factor of highest importance contains indicators of physical preparedness, and the third one - technical skills. In the case of U14 number of factors is already 7 the second one being morphological, the third one - anthropometric, and the fourth one defines the place of the physical preparedness for this age group. Eight-factor components are already observed in the case of U16. In the first one, the anthropometric indicators related to body length are a prerequisite for better achievement in the maximal vertical jump. Shooting for 2 and three points is the second component and the third one is related to body weight and measurements. The last eighth component is entirely composed of indicators of physical preparedness.

Discussion

Research results show that in the case of U12, U14, and U16 the physical development is dynamic, and laws of biological development characteristic for each age are observed. The most dynamic development of all indicators is observed within 12 to 14 years of age and that is also in connection with their age of puberty which is already the age of 14 and 16, in which case unsubstantial changes in the indicators are registered. For a basketball game, it is necessary for female players to be of bigger body height, have longer arms, and be physically stronger because when shooting or mastering the rebound under the basket and when playing defense, they will occupy a larger space and will be more stable in contact play with a defender. Taller players have higher blocking reach, cover wider space by arm span, and possess higher body mass, and absolute strength, which all contribute to successful one-on-one play under the 3.05-m basket (Zaric et al., 2018; Ranisavljev,

Mandic, Cosic, Blagojevic, & Dopsaj, 2020).

Dynamic development is also observed in the group of indicators of physical preparedness, assuming that this is also due to the specificity of the training process in basketball. Over 70% of the movements in basketball are of speed-force nature - the lower limbs are most actively involved and to a lesser extent are the upper limbs (Borukova, 2018). Characteristic of the process of basketball training is the increase of lower limbs strength after the age of 14 thus increasing agility and the work for speed endurance.

Regarding indicators of technical skills, it is normal to have the best results with U16. Measured characteristics of the technical skills by age have different structures in the function of the specified factors which, in our opinion is due to the age adaptation to the basketball training process and the sports experience of the people subject of the research. Sports technical qualities have to be perfected in relation to the development of their motive qualities as well (Sergiev, 2019).

The results obtained in this research show that the measured characteristics with regard to different ages have different structures in the function of the specified factors under the influence of different mechanisms with regard to the training process. In the case of U12 girls most important is anthropometric data and that provides an opportunity for a selection to be made of this age. With U14 skills in basketball technique are determined in the first place that is better if HE (cm) and VJ (cm) are of higher values. This will give them the opportunity to dominate in the 1v1 game with both physique and technique.

For U16 body lengths and MVJ (cm) are of decisive importance. The age of 16 sets the beginning of the transition to women's basketball which requires of players to have bigger body heights, be physically stronger, and be excellently trained in the technical aspect. This is a prerequisite for developing their basketball talent in the future. Body height significantly predicts success at FIBA-WWC, suggesting that talent identification and selection could be improved in female basketball (Zaric et al., 2020)

This study examines the hierarchical structure of physical development characteristics, physical preparedness, and technical skills of young female basketball players of U12, U14, and U16, and aims to derive the leading factor components for each age group which enables coaches to predict the development of basketball female players and work purposefully in the process of training. The main findings showed a specific change in the order of the factor components for girls by single age groups.

The research done shows that development of good female basketball players should start with a selection from U12 and up to U14 they should be trained in basketball skills and technique of the game and when the correctly selected girls are already U16 they should have the wanted profile of a basketball player - bigger body height, physically strong body and high level of technical skills. As a main limitation of the study, we can point out the impossibility to conduct the tests with all players taking part in the state championship for the respective age.

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Conflict of Interest

The author declares that there is no conflict of interest.

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