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ASSOCIATION OF PHYSICAL ABILITIES AND PHYSIOLOGICAL CHARACTERISTICS WITH COMPETITIVE EFFICACY OF U16 FEMALE BASKETBALL PLAYERS

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Abstract This study investigated the association of physical abilities and physiological characteristics with competitive performance of female basketball players under 16 years of age (U16). The sample included 30 players from the three best basketball clubs in U16 league of Serbia (age = 14.98 ± 0.68 years). Their maximal contractile force (F_{max}) and rate of force development (RFD_{max}) of leg and back extensors and finger flexors were assessed via maximal isometric leg press, dead lift, and handgrip. Their maximal strength of leg muscles was assessed by vertical counter movement jump and Abalakov vertical jump, while anaerobic power of legs with Lactate and heart rate characteristics were assessed using the 30-s Wingate test. Competitive basketball performance was evaluated via competency index calculated from the official statistics for each player. The association were statistically tested using the multiple regression analysis. The results revealed significant predictive value (R^2 = 0.462, p = 0.017) of physical and physiological profile of players in predicting competitive performance. Physical abilities and physiological characteristics of U16 female basketball players could be modeled and used as reference values for screening purposes in process of managing the training program of young players and for the checkpoints in development of players from young age to professional level.

Key words: basketball, game statistics, female athletes, laboratory testing

INTRODUCTION

Basketball is a game in which a team of five players needs to score a 3.05 m high basket, while another team is trying to stop them. A scored basket has a value of one, two, or three points, depending on the distance from which the basket is scored. The team that scores higher number of points is a winner. Three-point shots are typically scored from a 6.75 m distance, which requires good movement precision and consistency. It also depends on sufficient amount of movement on the court with and without the ball so the player gets into a favorable shooting position. Two-point shots are typically scored from mid-distance (i.e., inside the 6.75m-line), under the basket, and by dunking the ball into the basket. In each case, a player needs to work on getting into a position to attempt the shot and to be physically capable of playing against the defending player. On the other hand, defending team is acting to prevent the team in offense to score the basket, which as well requires large amount of different movements.

For the team to win, players need to be good in sprinting, changing directions, jumping, blocking, and pushing. Moreover, they need to be able to repeat these actions throughout the game and season. Therefore, a player’s competitive efficacy to a large degree depends on physical abilities and physiological profile of players [9,10,15]. Although players differ in physical abilities comparing between playing positions [9], they need to be physically ready to handle the tasks respective to their position. To that end, Delextrat and Cohen [1] reported significantly lower explosive power, agility, isokinetic strength of knee muscles, and the absolute strength of upper body in average compare to elite basketball players. Zaric et al. [15] showed that physical abilities predicted 84% of variance in match performance of young basketball player. In contrast, recent study on basketball players showed that NBA draft combine was a weak predictor of player's performance as it explained 24.7% of the variance in performance [12].

Current body of literature on physical abilities and players competitive efficacy is scarce. Studies utilized different test batteries as well as different groups of players. Moreover, competitive efficacy was not evaluated using the same procedures. Considering this, generalization of results and methods of performance prediction on wider population of basketball players is yet to be determined. The aim of our study was to investigate the prediction value of physical abilities and physiological characteristics in predicting competitive efficacy of female basketball players under 16 years of age (U16). We hypothesize that physical abilities and physiological characteristics will be a significant predictor of players' competitive efficacy. This could be of great value in selection and talent acquisition process as well as developing the model characteristics of female basketball players.

METHODS AND MATERIALS

EXPERIMENTAL APPROACH TO THE PROBLEM

This was a cross-sectional study that included laboratory and field data. The research included the assessment of physical abilities in laboratory setting and analysis of players' efficacy of young basketball players using official statists from games.

SUBJECTS

The sample consisted of 30 female basketball players from three best-ranked clubs in U16 basketball league of Serbia. The main characteristics were age = 14.98 ± 0.68 years; height = 174.31 ± 7.47 cm; mass = 67.09 ± 10.33 kg, and body mass index = 22.01 ± 2.60 kg/m². Their training history was 5.26 ± 2.08 years, in recent training history they were having five training sessions per week of mean duration of 97.17 ± 6.65 min, and they played one game per week. All subjects received a clear explanation of the study, including the risks and benefits of participation, and written informed consent was obtained prior to testing. Ethical committee of the Faculty of Sport and Physical Education, University of Belgrade, Serbia, approved the study design. The research was conducted according to Helsinki declaration on research including human subjects [14].

PROCEDURES

The assessment of physical abilities were conduct in one testing session between 09:00-11:00 am in Laboratory of the Faculty of Sport and Physical Education, University of Belgrade, Serbia. All subjects performed a 15-min warm up consisting of 10 min cycling ergometer and 5 minutes of dynamic stretching of the lower limbs, and practice of vertical jumps. After the warm up, subjects performed counter movement jump, counter movement jump with hand swing, isometric leg press, handgrip strength, isometric deadlift, and standardized 30-s Wingate test. For all tests, except for Wingate, subjects had two to three familiarization trials with sufficient rest. Afterwards, they performed two trials and better result was recorded for the analysis. The rest was two minutes between the trials and five to eight minutes between tests.

Players' efficacy was estimated from the data obtained from the official game statistics sheet from four different games. The first game subjects had played one week before the laboratory testing, the second game they had played three days before the testing, the third game they played three days after the laboratory testing, and the fourth game they played seven days after the testing.

COUNTER MOVEMENT JUMP (CMJ) AND COUNTER MOVEMENT JUMP WITH ARM SWING (CMJA)

For CMJ, the subject started by standing with both legs on the force platform ad hands fixed on their hips, following procedures reported elsewhere [15]. In short, participants performed short and explosive eccentric movement (i.e., half-squat) fallowed by quick and explosive concentric movement. The depth of eccentric movement was self-guided allowing them the best performance.

Following the CMJ assessment, CMJa was assessed. The CMJa was performed as previously explained in studies [6,15,17]. In short, the procedure was the same as the CMJ but subjects were allowed to use the swing of their arms for the best performance. The time spent in flight phase was used to calculate the jump height. The height jumped was measured to the nearest 0.1 cm. The validity and reliability of CMJ was reported to be high [7].

ISOMETRIC LEG PRESS (ILP), HANDGRIP STRENGTH (HGS), AND ISOMETRIC DEAD LIFT (IDL)

Subjects were seated in a custom-designed horizontal leg press with their hip, knee, and ankle extension angles at 110^0, 120^0, and 90^0, respectively [15,17]. They were instructed to press the platform connected to a force gauge. Maximal force (F_{max}) and rate of force development (RFD_{max}) of the right and left finger flexors were assessed using a handgrip dynamometer. The assessment was performed as per protocol previously reported in studies [2,15]. F_{max} and RFD of back and hip extensors were assessed by IDL that was performed with the bar connected to force gauge that was connecter to the floor via chan. The instruction was to contract tested muscles as strong and quick as possible, with emphasis on quickness of force production. They performed three consecutive 4-second contractions, with one minute in-between. The acquisition frequency was 500Hz, filtered by low pass filter of 10Hz with Butterworth filter of fourth order [5]. A software Isometrics Lite (Ver. 3.1.1) analyzed the signal. F_{max} and RFD_{max} were recorded for the analysis.

WINGATE TEST

Standardized 30-sekonds Wingate was used to asses peak power (W30PP [w]), average power (W30AP [w]), relative peak power (W30PPrel [W/kg]), and relative average power (W30AP [W/kg]) were assessed using. The heart rate was measured immediately after the test (HR_{0min}), three and five minutes after test (HR_{3min} and HR_{5min}). The lactate concentration level was measured from capillary blood sample which was collected after three and five minutes after the test (La_{3min} and La_{5min}) [1,15].

COMPETITIVE EFFICACY

Competitive efficacy of each player was defined according to previously reported procedure [15,16]. In short, the statistics sheet of each player was analyzed and the overall players contribution was calculated. The data included positive and negative indicators of players contribution. Positive were number of points, number of successful 3-poin shots, 2-point shots, and free throws, number of assists, number of rebounds, number of turnovers, number of fouls taken by player, and number of blocks. Negative indicators were number of missed shots, for 3, 2, and 1 point (free throws), number of personal fouls made by player, number of technical fouls, number of lost balls, and number of shots made by the guarded player.

The following formula was used: Competitive efficacy index (CEI) = (successful 3-point shots × 3 + successful 2-point shots × 2 + successful free throws + assists + rebounds + turnovers + of fouls taken by player + blocks) – (missed 3-point shots + missed 2-point shots + missed free throws + personal fouls made by player + number of technical fouls + number of lost balls + number of shots made by the guarded player). CEi was calculated after four games and the average value was used for the analysis

STATISTICAL ANALYSIS

Means, standard deviations, minimum and maximum, coefficient of variation and upper and lower limit of coefficient interval were calculated for all variables. Multiple regression analysis was used to determine the association of performance measures and physical abilities with CEi. Backward model was selected for the analysis. Level of significance was set at $p < 0.05$. All statistical analyses were computed using the Statistics Package for Social Sciences (Version 22.0; IBM Corporation, New York, USA).

RESULTS

Descriptive statistics for investigated variables are shown in Table 1. The obtained cV% shows indicated homogenous sample in all variables except in the CEi where the cV% was the largest.

Multiple regression analysis determined significant moderate prediction value of physical abilities and physiological characteristics in predicting CEi ($R^2 = 0.462$, adj. $R^2 = 0.321$, SEE = 6.946, F = 3.289, p = 0.017). Out of 14 extracted models of prediction, the simplest model was defined as the most approapriate including contractile characteristics of muscles, anaerobic power, muscular power, and the ability to recover faster (Table 2). The RHGSFmax was the most significant predictor, fallowed by the HR_{3min}, La_{3min}, and IDL_{RFDmax}.

The following model of predicting CEi was determined:

$$CEi = 13.107 + (RHGS_{Fmax} \times 0.096) - (La_{3min} \times 2.607) - (IDL_{RFDmax} \times 0.002) + (CMJ \times 0.879) + (HR_{5min} \times 0.282) - (HR_{3min} \times 0.456)$$

Table 1. Descriptive statistics all investigated variables

Variables	Mean	Standard Deviation	cV%	Minimum	Maximum	95% Confidence Int.	
						Lower bound	Upper bound
CMJ [cm]	24.45	3.39	13.88	18.37	31.52	23.29	25.65
CMJa [cm]	28.90	4.18	14.48	21.63	38.18	27.45	30.40
IDL_{Fmax} [N]	831.23	148.61	17.88	527.00	1190.00	776.20	884.26
IDL_{RFDmax} [N/s]	3571.63	1380.79	38.66	1548.00	7300.00	3074.13	4080.34
$LHGS_{Fmax}$ [N]	286.23	41.70	14.57	193.00	419.00	272.74	301.33
$LHGS_{RFDmax}$ [N/s]	2032.20	394.43	19.41	1064.00	3166.00	1899.18	2177.05
$RHGS_{Fmax}$ [N]	302.03	48.74	16.14	204.00	444.00	285.22	320.77
$RHGS_{RFDmax}$ [N/s]	2182.23	458.03	20.99	1407.00	3064.00	2020.25	2346.80
ILP_{Fmax} [N]	1978.98	540.54	27.31	1082.48	3343.33	1799.32	2188.23
ILP_{RFDmax} [N/s]	9210.94	3029.83	32.89	2805.07	16059.21	8137.88	10316.37
W30PP [W]	677.38	102.36	15.11	554.77	964.62	642.88	716.18
W30PP [W/kg]	10.13	0.84	8.33	8.28	11.77	9.85	10.42
W30AP [W]	500.75	69.69	13.92	404.95	710.81	477.80	528.83
W30AP [W/kg]	7.49	0.55	7.34	6.49	9.14	7.31	7.69
HR_{0min} [b/min]	173.47	9.12	5.26	155.00	197.00	170.27	176.57
HR_{3min} [b /min]	108.83	13.19	12.12	82.00	135.00	104.37	113.20
HR_{5min} [b /min]	96.83	15.22	15.71	62.00	124.00	91.30	102.03
La_{3min} [mmol/L]	9.72	1.35	13.88	6.60	12.20	9.18	10.17
La_{5min} [mmol/L]	10.30	1.12	10.90	7.80	12.20	9.91	10.70
CEi [index]	7.26	8.43	116.22	-1.25	29.00	4.43	10.35

CMJ - counter movement jump; *CMJa* - counter movement jump with arm swing; IDL_{Fmax} - maximal force of isometric dead lift; IDL_{RFDmax} - maximal rate of force development of isometric dead lift; $LHGS_{Fmax}$ - maximal force of left hand grip; $LHGS_{RFDmax}$ - maximal rate of force development of left hand grip; $RHGS_{Fmax}$ - maximal force of right hand grip; $RHGS_{RFDmax}$ - maximal rate of force development of right hand grip; ILP_{Fmax} - maximal force of isomteric leg pres; ILP_{RFDmax} - maximal rate of force development of isometric leg press. *W30PP* - peak power from Wingate test; *W30PP* - relativezed peak power from Wingate test; *W30AP(W)* – mean power from Wingate test; *W30AP(W/kg)* - mean relativized power from Wingate test; HR_{0min} - heart rate at the end of Wingate test; HR_{3min} - heart rate after 3-min rest; HR_{5min} - heart rate after 5-min rest; La_{3min} - blood lactate level after 3-min rest; La_{5min} - blood lactate level after 5-min rest; CEi_s - competitive efficacy

Table 2. Regression coefficients

Model	**Unstandardized coefficients**		**t**	**p**
	B	**Std. Error**		
Constant	13.107	15.896	0.825	0.418
$RHGS_{Fmax}$ [N]	0.096	0.032	3.033	0.006
La_{3min} [mmol/L]	-2.607	1.060	-2.460	0.022
IDL_{RFDmax} [N/s]	-0.002	0.001	-2.236	0.035
CMJ [cm]	0.879	0.456	1.929	0.066
HR_{5min} [b/min]	0.282	0.162	1.738	0.096
HR_{3min} [b/min]	-0.456	0.182	-0.713	0.020

DISCUSSION

This study investigated the association of physical abilities and physiological characteristics with competitive efficicy of U16 female basketball players. The main findings showed significant association of physical and physiological attributes of players with their CEi. The regression analysis determined that 32% of variance in

CEi could be explained by $RHGS_{Fmax}$, La_{3min}, IDL_{RFDmax}, CMJ, HR_{5min}, and HR_{3min} of players. Therefore, these physical abilities and physiological characteristics should be considered in talent detection and selection process when building the basketball team.

From the space of physical abilities, $RHGS_{Fmax}$ was the strongest predictor of players efficacy, suggesting that a strong right hand grip of players is an important role in players efficacy. It is of note however, that 85% of players were right-hand-dominant. The importance of maximal hand grip force could be attributed to the notion that hand grip reflects phenotype of a person in terms of general strength of one's body [4]. Thus, $RHGS_{Fmax}$ could be included among the important indicators for talent acquisition in basketball [11,13]. The second variable from the space of physical abilities that was significant predictor is IDL_{RFDmax} or the ability to activate hip and back extensors as fast as possible as strong as possible. The negative association of this indicator is not clear. However, a twice-higher between-subject variation in IDL_{RFDmax} than in IDL_{Fmax} suggests different adaptation stages among players. Furthermore, some may be strength, while others may be power dominant. Given that the coefficient for IDL_{RFDmax} was small, it could be that IDL_{RFDmax} adjusts for strength and power as optimal rather than the-higher-the-better approach is more likely to select with higher precision. For instance, it could be that some of the players from the sample were recruited into the team based on their physical characteristics rather than on playing skill, which this model seems to recognize.

The relative strength of lower limbs was the last variable that entered the prediction model. Although individually it was slightly above the significance level, it adds to the precision of prediction of CEi. The coefficient suggests that higher CMJ was associated with higher CEi. Vertical jump is one of the most important parts of basketball game (i.e., about 60 jumps per game) whether in offense or defense so being able to jump high plays an important role in selection process. The importance of vertical jump was confirmed in other studies as well [1,3,8].

Considering the physiological characteristics, La_{3min}, HR_{5min} and HR_{3min} were extracted as significant predictors of players' efficacy. Negative association of La_{3min} and HR_{3min} indicates that players whose physiological load was lower for maximal W30PP also had higher CEi. Negative association could also mean that those with more efficient aerobic system recovered faster by metabolizing higher amount of blood lactates, providing that they could perform more high-intensity bouts throughout the game. Positive association of HR_{5min} with CEi suggest that players who obtained higher oxygen depth, hence higher maximal power, tend to have higher CEi as well. Therefore, anaerobic and aerobic metabolisms are of high importance for the players' competitive efficacy and should be taken into account during the selection process. Moreover, both processes are the reflection of adaptation to training and should be screened on a regular basis for the accuracy of periodization.

CONCLUSIONS

This research illustrated that there are relationships between physical abilities, physiological characteristics, and basketball competence of young female players. These relationships had significant prediction value and should be considered for the purposes of training process, talent acquisition, and selection. Methodology used in this research provides a valid tool for head coaches, strength and conditioning coaches, and team managements for aforementioned purposes.

PRACTICAL APPLICATION

Methods used in this study could be used as a screening tool at certain points of training periodization as it could provide the information whether applied training provided planned adaptation. Furthermore, it could be used to screen for talented players, and for the young players who would enter the team or pass to more advanced training processes.

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