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ASSESSMENT OF 16-YEAR-OLD FEMALE BASKETBALL PLAYERS WITH CHRONOJUMP SYSTEM

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ABSTRACT

In the basketball game, lower extremity strength plays a key role in various game actions. The jumping mat (Chronojump), an open-source (free software and open hardware), is available to the public on official servers, emphasizing peer review and corrections by the user community. The aim of this study was to establish the explosive power of the lower limbs of 16-year-old female basketball players from the Bulgarian National Basketball Team. We used specialized software, a signal transducer, and an electro-contact mat Chronojump. The subject of the study was the explosive power of the lower limbs of 16-year-old female basketball players from the national team of Bulgaria. The object of the study was the performance of the Chronojump platform tests to establish the explosive strength of the lower limbs. The study was conducted among 16 active female basketball players selected for the Bulgarian national team. Each participant performed all jumps at the same time of day. They performed CMJ - 90-degree squat jump; SJ - Squat, two-second hold, and jump; CMJAT - Jump with arms extended forward and up; RCMJ - Manipulative 90-degree squat jump; Stiffness - Manipulative ankle jump. The test's mathematical-statistical results were processed with variance analysis and One-way ANOVA, with a critical value of the F-criterion (F = 2.38) and high statistical reliability (Pt ≥ 95%). Results showed that hand involvement is key in rebounding. In terms of jumping endurance and explosiveness quotient, female athletes had a lower level of development. This research has the potential to significantly impact the training and performance of female basketball players.

Keywords: *Chronojump platform, explosiveness coefficient, basketball*

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INTRODUCTION

A vertical jump is one of the most important factors for assessing the muscle strength of the lower limbs. According to sports specialists, vertical jumps provide information about the level of basketball players' athleticism. There are various methods and protocols for assessing the muscle strength of lower limbs, such as vertical jump tests (Baca, 1999) and tests based on software applications (Driller et al., 2017), but, in general, we can divide them into three main groups. First, the height of the jump can be calculated with force plates through a digital integration of the vertical powers of the earth reaction (Whitmer et al., 2014). Alternatively, accelerometers are portable devices that can calculate the height of the jump through the assessment of vertical forces applied by the body weight and vertical accelerations (Choukou, Laffaye, Taiar, 2014; Borges et al., 2017). Second, the height of the jump can be obtained as the difference between the height of the peak and the basic height of the movement of the body's center of gravity (the jump is shot) (Kibele, 1998; Barris & Button, 2008). Third, the time interval between take-off and landing can be transformed into jump height through a simple kinematic equation with the help of simple time-measuring devices that measure the time of an athlete's flight (Hatze, 1998).

These instruments are widely used by sports specialists due to their accessibility, low price, and easy application. The contact mat is the most popular instrument in this group. It consists of an electric switch built into the mat, which is activated under pressure as a result of body weight, and therefore, the time of the flight can be assessed automatically (García-López et al., 2008). Chronojump Boscosystems (Barcelona, Spain) is one of these models. It has an open code (free software and open hardware). The software (the initial code) and the hardware (project files) are accessible to the public and can be found on official servers. Partnership checks and corrections are what is sought. Despite free access, no research has been done among 16-year-old Bulgarian female basketball players with this system so far. To date, only terrain sports-pedagogical tests have been applied to assess vertical jumps and establish the explosive power of lower limbs. The standing vertical jump and the approach jump are the most applicable. The assessment is made by the researcher or the coach, and the lack of an electronic assessment device is a premise for mistakes or inaccurate recordings.

The aim of this study was to establish the explosive power of the lower limbs of 16-year-old female basketball players from the Bulgarian National Basketball Team. We used specialized software, a signal transducer, and an electro-contact mat Chronojump.

METHODOLOGY

Research Methods

The study examined the explosive power of the lower limbs of 16-year-old female basketball players from the Bulgarian National Team.

The study's object was to establish the explosive force of the lower limbs using the indicators of the Chronojump platform tests.

The research was done among 16 active female basketball players selected for the Bulgarian National Basketball Team (mean age 15.3±0.8 years, body weight 73.9 ± 9.2 kg, stature 176.8 ± 12.6 cm). Each participant performed all jumps at the same time of the day.

Ethics

All athletes participated voluntarily in the study and received no money or financial compensation.

The study protocol conformed to the guidelines of ethical principles of the Declaration of Helsinki. All participants understood the study's aims and risks before the beginning of the study, and they signed informed consent.

None of the participants declined participation in the study except those who were injured or not feeling well.

Procedures

This empirical study consisted of manifold assessments of the maximum height of the jumps the participants performed within one test session. Prior to jumping, the players had a standard 15-minute warm-up. Then, they were instructed about the nature of the jumps so that they could achieve the proper jumping technique and maintain their balance on landing.

The following jumps were performed on the test day:

- **Counter Movement Jump (CMJ)** – 90-degree squat jump**.** In the beginning, the player stands tall, with their feet shoulder-width apart and hands on the waist. After the starting signal is given, the player squats by flexing the knees at 90 degrees. Then, the player jumps as high as possible, trying not to move forward, backward, or sideward. Upon landing, the player returns

to a standing position without moving and waits for the operator to finish the test. Througout the assessment, the player's torso should be upright, with hands on the waist.

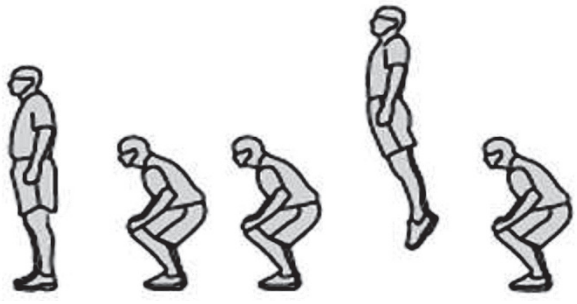

Figure 1. *Counter Movement Jump*

- **Squat Jump with a two-second hold (SJ)** – Squat, two-second hold, and jump. In the beginning, the player stands tall, with their feet shoulder-width apart and hands on the waist. After the starting signal is given, the player squats by flexing the knees at 90 degrees. They hold the position for two seconds. From this position, the player should perform a vertical jump without leaning or going lower in the squat to eliminate elasticity. If a player moves downward, the test will not be valid. Upon landing, the player returns to a standing position without moving and waits for the operator to finish the test. Throughout the assessment, the player's torso should be upright, with hands on the waist.
- **Counter Movement Jump with Arm Thrusts (CMJAT)** – Jump with arms extended forward and up. Initially, the player stands tall, with feet shoulder-width apart and hands on the waist. After the starting signal is given, the player squats by flexing the knees at 90 degrees – the arms help by moving backward. Upon landing, the player returns to a standing position without moving and waits for the operator to finish the test. Throughout the assessment, the player's torso should be upright.

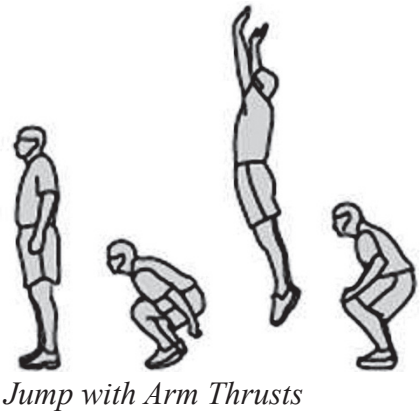

Figure 2. *Counter Movement Jump with Arm Thrusts*

- **Repeated Counter Movement Jump (RCMJ)** – Manipulative 90-degree squat jump (30-second duration). In the beginning, the player stands tall, with their feet shoulder-width apart and hands on the waist. After the starting signal is given, the player performs a series of squats by flexing the knees at 90 degrees. Upon

landing, the player returns to a standing position without moving and waits for the operator to finish the test. Throughout the assessment, the player's torso should be upright, with hands on the waist.

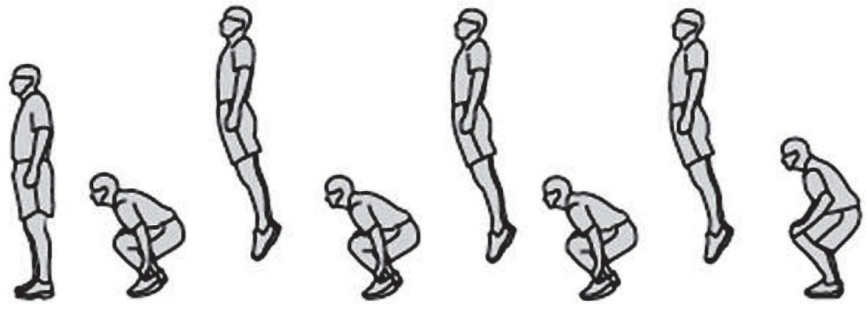

Figure 3. *Repeated Counter Movement Jump*

- **Stiffness –** Manipulative ankle jump **(30-sec duration).** In the beginning, the player stands tall, with their feet shoulder-width apart and hands on the waist. After the starting signal is given, the player performs a series of jumps over a preliminarily set period. The first jump may be performed with a squat to 90 degrees, but the following jumps should be executed with straight legs. The player should try to stay in the air longer than when they have contact with the ground. Upon landing after the final jump, the player returns to a standing position without moving and waits for the operator to finish the test. Throughout the assessment, the player's torso should be upright, with hands on the waist.

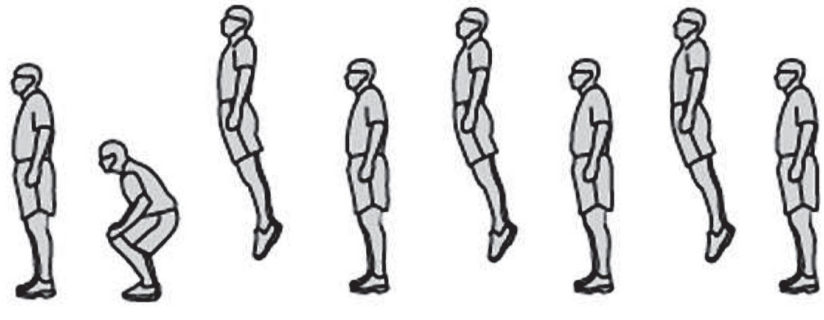

Figure 4. *Stiffness*

After that, the researched players performed two repetitions of the jumps with a one-minute break between the consecutive jumps. They were told to repeat each jump they had performed improperly. Only the successful jumps were taken into consideration.

The test's mathematical-statistical results were processed with variation analysis and One-way ANOVA (Gigova, 2002), with a critical value of the *F*-criterion ($F = 2.38$) and high statistical reliability ($Pt \geq 95\%$).

Data Collection

In this experiment, we used a Chronojump mat with an open code. The system includes a contact mat consisting of two isolated electric switches serving as an electric circuit breaker dependent on the pressure, with a configuration with an open chain that closes when the player stands on the mat. The computer-based Chronojump microcontroller is connected to the mat. It calculates the time of the flight with an accuracy of 1 ms.

All the jumps, except for CMJAT, start and finish with hands on the waist. All the jumps start after a squat at 90 degrees in the knee joints. Explosiveness coefficient – the assessment is based on the recorded indicators of the average height of the jumps, the total support time, and the number of jumps performed within 30 seconds.

RESULTS

Table 1 presents the results from the jump indicators. The analysis shows that the average maximal jump was 26.50 cm, but there was a maximum value of 32.40 cm. The arc jump that includes the arms had a higher value of 30.69 cm, while the squat jump had the lowest value of 24.51 cm. The distribution of values was customary for all indicators, according to As and Ex, which were within ±1. All values of V were above 10% but below 30%, which, according to sports statistics, shows that the researched sample was relatively homogeneous.

Table 1. *Mean value and variability of the indicators of vertical jump*

Indicators	*n*	X min	Xmax	R	*M*	S	V	As	Ex
1. Counter Movement Jump	16.00	18.60	32.40	13.80	26.50	4.020	15.16	-0.558	-0.099
2. Squat Jump (2 sec.)	16.00	16.40	30.10	13.70	24.51	3.980	16.25	-0.555	-0.176
3. Counter Movement Jump with arm Thrusts	16.00	22.60	36.80	14.20	30.69	4.210	13.73	-0.302	-0.804

Table 2 presents the results from the indicators of the explosiveness coefficient RCMJ in manifold jumps with a squat at 90 degrees for 30 seconds. The analysis shows that the average maximal height of the jump was M_4=27.18 cm, but there was also a maximal value of 36.40 cm. The average number of performed jumps was M_5=33.56 but with an average jump height of M_6=18.78 cm and a total support time of M_7=16.69 s. The average support time was M_8=0.52 s. The distribution of the values was customary for all indicators; both As and Ex were within ±1. Therefore, the research sample was again relatively homogeneous. The explosiveness coefficient for RCMJ refers to the level of development of the explosive power. A coefficient above 0.500 is regarded as a good one. The value for the researched sample was M_9=0.400. Most female athletes' values were close to the good one, but the group, as a whole, was below the level of the good coefficient.

Table 2. *Mean value and variability of the indicators of explosiveness coefficient RCMJ – manifold jumps from squat at 90 degrees (30 s)*

Indicators	*n*	X min	Xmax	R	*M*	S	V	As	Ex
4. Maximal height	16.00	19.40	36.40	17.00	27.18	5.260	19.37	0.415	-1.207
5. Number of jumps	16.00	26.00	43.00	17.00	33.56	4.940	14.72	0.611	-0.023
6. Average height	16.00	13.80	25.90	12.10	18.78	3.720	19.79	0.710	-0.175
7. Total support time (sec)	16.00	21.70	13.00	8.70	16.69	2.490	14.92	0.261	-0.513
8. Average support time (sec)	16.00	0.84	0.35	0.48	0.52	.140	27.65	0.681	-0.064
9. Variability coefficient	16.00	0.18	0.70	0.53	0.40	.160	39.30	0.712	-0.398

Table 3 presents the results from the indicators of the explosiveness coefficient Stiffness in manifold jumps from ankles for 30 sec. The analysis shows that the average max-

imal number of jumps was M_{10}=46.69, but there was again a maximal value of 52, which shows almost two jumps within a second. This provides information about very agile lower limbs in the ankle joint. The average height of the jump was M_{21}=21.19 cm, but the average support time was M_{13}=0.23 s. The indicators for the average support time, total support time, As, and Ex show that the distribution of the values was different from the customary one and that the researched sample was highly homogeneous regarding the number of the jumps V_{10}=6.06%, but along all the other indicators, the researched sample was relatively homogeneous. The explosiveness coefficient in Stiffness refers to the level of development of the explosive power. A coefficient above 1.200 is regarded as a good one. The value for the researched sample was M_{14}=0. 960, but there were some players whose values were close to the good one.

Table 3. *Mean value and variability of the indicators of explosiveness coefficient Stiffnees – manifold jumps from ankles (30 s)*

Indicators	*n*	X min	Xmax	R	*M*	S	V	As	Ex
10. Number of jumps	16.00	42.00	52.00	10.00	46.69	2.850	6.09	0.004	-0.490
11. Average height	16.00	15.90	27.10	11.20	21.19	3.110	14.69	0.233	-0.575
12. Total support time	16.00	15.70	8.90	6.80	10.58	1.640	15.50	2.119*	6.799*
13. Average support time (sec)	1600	0.37	0.18	0.20	0.230	.040	18.88	2.608*	8.703*
14. Variability coefficient	16.00	0.43	1.32	0.90	0.960	.220	23.19	-0.661	0.892

Table 4 presents the results from the elasticity, coordination, and endurance indicators.

Table 4. *Mean value and variability of the indicators of elasticity, coordination, and endurance*

Indicators	*n*	X min	Xmax	R	*M*	S	V	As	Ex
15. Elasticity (%)	16.00	1.70	18.30	16.60	7.60	4.340	57.06	1.082	1.165
16. Coordination (%)	16.00	-0.10	38.10	38.20	16.45	9.250	56.21	0.770	1.178
17. Endurance	16.00	0.51	0.77	0.26	0.67	.080	11.48	-0.343	-0.771

The analysis shows that the % of elasticity had a mean value of M_{15}=7.60%, and coordination was M_{16}=16.45%. The closer to 1 the value of the endurance coefficient is, the better it is. When analyzing the results, we must consider the jumps' height because the coefficient is calculated based on the ratio between the last three jumps and the first three jumps. The value of the coefficient was M_{17}=0.67. This value is lower than 1 and shows that the researched female players did not have a good level of jumping endurance. However, we believe it is expected, provided that they were in the preliminary stage of their preparation.

DISCUSSION

This study aimed to analyze the vertical jump and jumping endurance of female basketball players with a Chronojump mat with an open code. Pueo et al. (2020) compared the results from Chronojump with those from a patented jumping mat Globus. They found that the jumping mat with an open code was a valid and reliable tool for assessing the vertical jump height (Pueo et al., 2020). The Chronojump jumping mat is reliable for measuring CMJ intra- and within-sessions. Therefore, it is a proper measuring device to take data on the field (Villalon, 2024).

To determine whether there were differ-

ences in the explosive power between the first three groups of jumps – countermovement jump, squat jump (2 sec), and countermovement jump with arm thrusts (arc jump), we used ANOVA. The results show that the inclusion of the arms influenced the performance to a great extent. Between Groups showed a high value of F= 9.63, while F_{emp}=3.23. Effect size Cohen's d=.654 also showed significant differences (above 0.40). This means that the differences between the groups of jumps were statistically reliable, which was supported by a guaranteed probability of P=99.97.

The explosiveness coefficient in RCMJ showed that the female athletes from the national team had not developed their explosive power to the required level. The explosiveness coefficient in Stiffness also showed a lower level of development of the athletes' explosive power.

The last group of indicators showed that the researched athletes lacked a good level of jumping endurance, coordination, and lower limb elasticity. However, due to their preliminary preparation stage, we believe this was to be expected and can be improved in the training process.

CONCLUSION

The data from this research show that the obtained reliability values allow us to view the Chronojump mat as a reliable instrument for assessing the explosive power of the lower limbs of female basketball players. Therefore, we have proven that it is useful for assessment in field conditions. Nevertheless, we should consider that the inclusion of the upper limbs changes the results significantly, especially in cases when there are little changes in the production of the vertical jump. Despite this, Chronojump allows coaches and fitness specialists to observe the athletes with sufficient reliability and arrive at more precise conclusions. We recommend that the protocols be considered and applied as much as possible to minimize the mistakes in the assessment process since they could be a source of loss of sensitivity.

To establish the explosive power of the lower limbs, one should select the tests with caution, and the analysis should consider the inclusion of the upper limbs. The basketball game is characterized by lots of jumps without the inclusion of the arms. Therefore, surveys with Chronojump platforms may prove helpful for the coaches. The results provide a baseline for future research on the strength of the torso and limbs.

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Conflicts of Interest

The authors declare no conflict of interest.

REFERENCE

Baca, A. (1999). A comparison of methods for analyzing drop jump performance. *Med Sci Sports Exerc. 31*(3):437–42.

Barris, S., Button, C. (2008). A Review of Vision-Based Motion Analysis in Sport. *Sport Med.38*(12):1025–43.

Borges, T.O., Moreira, A., Bacchi, R., Finotti, R.L., Ramos, M., Lopes, C.R. & Aoki, M.S. (2017). Validation of the VERT wearable jump monitor device in elite youth volleyball players. *Biol Sport. 34* (3):239–42.

Choukou, M.A., Laffaye, G. & Taiar, R. (2014). Reliability and validity of an accelerometric system for assessing vertical jumping performance. *Biol Sport.31*(1):55–62.

Driller, M., Tavares, F., McMaster, D. & O'Donnell, S. (2017). Assessing a smartphone application to measure counter-move-

ment jumps in recreational athletes. *Int Journal Sports Sci Coach.12* (5):661–4.

García-López, J., Peleteiro, J., Rodgríguez-Marroyo, J.A., Morante, J.C., Herrero, J.A. & Villa, J.G. (2005). The validation of a new method measures contact and flight times during vertical jumps. *Int Journal Sports Med.26*(4):294–302

Gigova, V. (2002). *Statisticheska obrabotka i analiz na danni*. Sofia. NSA – IPB. // Гигова, В. (2002). Статистическа обработка *и* анализ на данни. София. НСА – ИПБ.

Hatze, H. (1998). Validity and reliability of methods for testing vertical jumping performance. *Journal Appl Biomech.14*(2):127–40.

Kibele, A. (1998). Possibilities and Limitations in the Biomechanical Analysis of Countermovement Jumps: A Methodological Study. *Journal Appl Biomech.14*:105–17.

Pueo, B., Jimenez-Olmedo, J.M., Lipińska, P., Buśko, K. & Penichet-Tomas, A. (2018). Concurrent validity and reliability of proprietary and open-source jump mat systems for the assessment of vertical jumps in sport sciences. *Acta Bioeng Biomech.20*(4):51-57.

Pueo, B., Lipinska, P., Jiménez-Olmedo, J. M., Zmijewski, P. & Hopkins, W. G. (2017). Accuracy of Jump-Mat Systems for Measuring Jump Height. *International Journal of Sports Physiology and Performance, 12(7),* 959–963. DOI: 10.1123/ijspp.2016-0511

Pueo, B., Penichet-Tomas, A. & Jimenez-Olmedo, J.M. (2020). Reliability and validity of the Chronojump open-source jump mat system. *Biol Sport. Sep37*(3):255-259. DOI: 10.5114/biolsport.2020.95636.

Villalon, L., Jimenez-Olmedo, J.M., Aparicio-Aparicio, I. & Sanchis-Sanchis, R. (2024). Reliability of countermovement jump estimation using the Chronojump jump mat: Intra-session and within-session. *Journal Physic. Educ. Sport*, *24*, 133–140. DOI: 10.7752/jpes.2024.01017.

Whitmer, T., Fry, A.C., Forsythe, C., Andre, M.J., Lane, M.T., Hudy, A. & Honnold, D. (2014). Accuracy of a Vertical Jump Contact Mat for Determining Jump Height and Flight Time. *Journal strength Cond Res.29*(4):877–81.

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