Almir Atiković[1], Sunčica Delaš Kalinski[2] , Muhamed Tabaković[3], Elvir Kazazović[3] and Senad Turković[3]

Effects of drop jumps on gymnastics basic jump

[1]*Faculty of Physical Education and Sport, University of Tuzla, Bosnia and Herzegovina*
[2]*Faculty of Kinesiology, University of Split, Croatia*
[3]*Faculty of Sport and Physical Education, University of Sarajevo, Bosnia and Herzegovina*

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Abbreviations: CMJ, countermovement jump; CMJ-fa,countermovement jump with the free arms; DJ, drop jump; SJ, squat jump; BJ, bunny jump.

Abstract
The aim of this study was to investigate the relationship and effect between mechanical output in maxmium vertical and horizontal jumping students 3 year of Faculty of PE and Sport, University of Tuzla. On the sample consisted of female (n=30) and male students (n=37). Sample of depenedent variables were drop jumps from 20, 40, 60, 80, 100 cm. A sample of independent variables included only one variable bunny jump. All data was analyzed using Tanita TBF-300A, Optojump, Brower Timing Systems and SPSS 17.0. With regression analysis explained (R Square) 34% of the common variables with criteria. Analyzing the effect of individual variables one can see that the only statistically significant effect on the criterion variable is a variable drop jump from 80 cm (Beta: 0.611, $p<0.05$).

Keywords: **Drop Jumps, Bunny Jumps, Optojump, Explosive power of lower limbs**

Sažetak
Cilj ovog rada bio je ispitati donose bi uticaj između ispoljavanja maksimalne vertikalne i horizontalne komponentne odrazna, kod studenata 3 godine Fakulteta za tjelesini odgoja bi sporit, Univerziteta u Tuzli. Uzorak ispitanika sastojalo se od (n = 30) studentima i (n = 37) studenata. Kao uzorak zavisnih varijabli uzeti su dubinski skokovi sa visina od 20, 40, 60, 80, 100 cm. Za uzorak nezavisnih varijabli uzeta je samo jedna varijabla zečji uskok naprijed. Svi podaci analizirani su uz pomoću elektronske vage Tanita TBF-300A, Optojump-a, laserskim elektronskim sistemom mjerenja vremena i statističkim paketom SPSS 17.0. Sa regresionom analizom objašneno je 92% varijabiliteta sa kriterijem. Analizirajući učinak pojedinih varijabli može se vidjeti da je jedini statistički značajan uticaj na kriterijske varijable imala varijabla dubinski skok sa 80 cm (Beta: 0,611, $p<0,05$).

Introduction

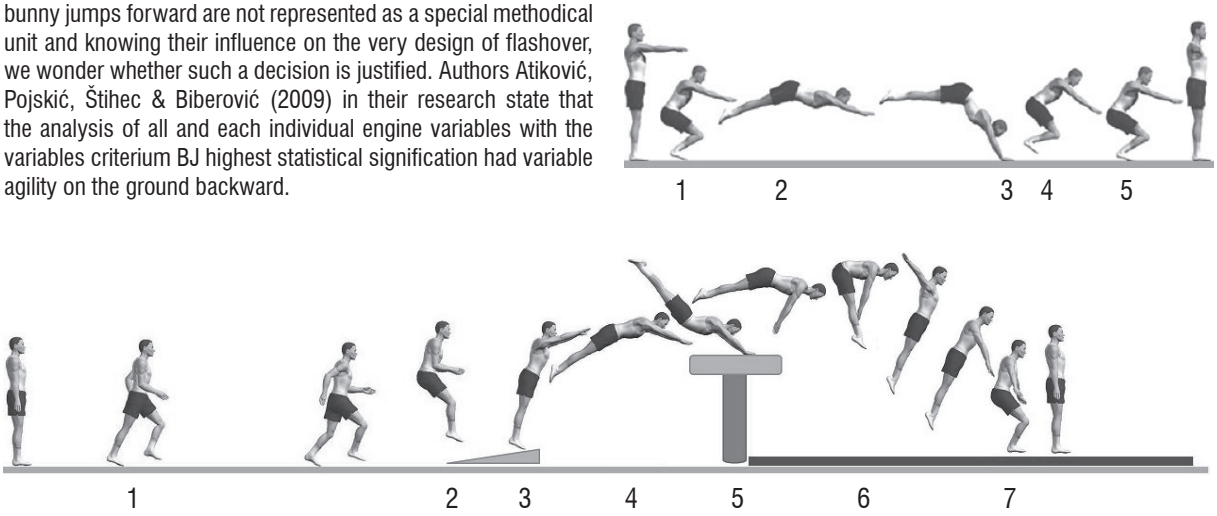
Arms and legs muscle power in general, and vertical jump performance in particular, are considered as critical elements for successful athletic jumps and bunny jumps performance. In scientific literature results of human muscle power testing are usually reported either in absolute (watts; W) or in per-body mass ratio standards (W/Kg) values. Action of muscles can be presented in three main ways of muscle activity: concentric contraction (C), ecscentric (E) and isometric (I), where the distance is constant, only changes muscle tone Hay and Reid (1982).

The importance of gymnastics elements bunny jump (BJ) forward (Picture 1) is reflected in the fact that this jump which is performed on the ground in its structure *has five stages* (taking off, first flight phase, taking weight on hands, second flight phase, two-footed landing), that is 1/7 (Picture 2) of the element on gymnastics valut. Out of seven stages of valut jump (Prassas, 2002; Čuk & Karácsony, 2004, Ferkolj, 2009, Begatović, Čuk & Atiković, 2011), the BJ we can use it as a warm up and easier way of learning elements of jump in an analytical method which is most commonly used while learning gymnastics elements like these. The first phase is a sprint towards the vault. This is an important phase because the following phases are dependent on it Čuk, Bricelj, Bučar, Turšič, & Atiković (2007). The jump on the springboard must be completed with minimum loss of sprint speed. Good and fast run-up allows a good reflection, and good reflection the good performance of flashover Ferkolj (2010). Antonov (1975) and Semenov (1987) measured the distance between the spring at springboard between 2.3-2.8 m. Flight time is depended on the speed of running and force of the reflection. When analyzing the data used in this work, most of the gymnasts had the time 0.24 to 0.30 s. Čuk & Karácsony (2004) found that top gymnasts spent only 0.24 s to complete the take-off phase on the springboard following the sprint approach. The time of the first flight phase depends on the relationship between horizontal and vertical velocity (Prassas, 2002). Analysis of the results in the example by Ferkolj (2007) showed that all the components of velocity in (x, y, xyz) axis differ in percentage. Velocity component in x-axis is reduced by 31.33%, the y-axis increased by 76.09% while the overall velocity component in xyz axis decreased by 10.60%. Analyzing this stage of flashover, the authors found the following usage of the time with the jump. Semonov (1987) usage of the time is generally 0.13 to 0.15 s. Čuk & Karácsony (1995) have established 0.08 s for a simple jump type stoop. In his research the author Ferkolj (2010) found that at the first hand contact with the table, overall speed (xyz) is 5.724 m/s. Atiković (2011) analyzes that the time of the second flight phase for easy jumping types stoop and hecht ranges from 0.70 to 1.20 s heavy jump type Dragulescu piked. Landing is the last, where in a very short time, stopping the gymnast must produce a force to stop the movement and rotation.

BJ forward are one of the most important elements in gymnastics on the vault. They require eccentric reflection, the head is not too obscure in the phase of flight. Landing is in use on the hands. The

impact on the development of motor skills is important and that especially relates to the coordination and strength Begatović, Čuk, & Atiković (2010). It is interesting that in the school curriculum, bunny jumps forward are not represented as a special methodical unit and knowing their influence on the very design of flashover, we wonder whether such a decision is justified. Authors Atiković, Pojskić, Štihec & Biberović (2009) in their research state that the analysis of all and each individual engine variables with the variables criterium BJ highest statistical signification had variable agility on the ground backward.

Picture 1. *Changes the body positions in the important bunny jump phases (1-5)*



Methods

Sample of the examines

The sample consisted of female (n=30) and male students (n=37) 3 years for the Faculty of PE and Sport University of Tuzla, which are regularly attended classes in the Artistic Gymnastics twice a week by 60 minutes.

Sample of the variables

Anthropometry and body composition Height and body mass were measured before all tests physical fitness abilities. Body height was measured using Martin's anthropometer with precision of 0.1 cm. Harpenden skinfold caliper are used in the measurement of skinfold thickness and the estimation of total body fat. body type (standard), weight (kg), body mass index (kg/m^2), basal metabolic rate (kJ), basal metabolic rate (kcal), impedance (Ω), Fat%, fat mass (kg), fat free mass (kg) total body water (kg), was measured using a Tanita TBF-300A Pro Body Composition analyzers scales with precision of 0.1 kg. The components of the body composition were estimated based on the reactance and resistance measured by bioelectrical impedance. Students and students were barefooted during measurements.

Physical fitness tests Physical fitness was measured using the EUROFIT test battery. This battery consists of several tests which measure the basic motor capacity of the subjects. All tests were performed in the under standardized conditions. To measure the characteristics of drop jumps (DJ) we used the laser system Optojump length of 2 m. Optojump has high values of reliability, time series are measured in 1/1000 s. Optojump we measure the following variables: total time (mm:ss), specific energy (J/Kg) total energy (J), specific power (W/Kg), time of contact (s), time of flight (s), height (cm), power (W/Kg), frequency (stride/s), number of jumps (freq.).

Data analyzes methods

For measuring bunny jumps distance (cm) and speed passage at 3, 6, 9 m we used Brower Timing Systems - Wireless Sprint System. Times accurate to 1/100th of a second. Measured variables of BJ were: time of hand support time (s), legs support time (s), total time flight phase (s). All jumps was recorded with two SVHS cameras and in frquency of 60 frame per second. The cameras were positioned so as to capture all important phases. Data book was made in several parts: transfer of video records of movement quantitaive data, edit that made data into Excell 2007. Data obtained in this study were analyzed using a software system for multivariate and univariate data analysis SPSS 17.0 (Statistical Package for the Social Sciences) data processing was performed at the Faculty of PE and Sport of Tuzla, University of Tuzla. We used standard statistical procedures to determine the following basic parameters descriptive variables. Applying the analysis of the intercorrelation matrix of variables (Correlations) determined the contents and value of the matrix of correlation coefficients. We use Kolmogorov-Smirnov test to determine the normality of distribution of the results for further multivariate analysis. By regression analysis we try to determine whether the BJ is dependent on some drop jumps and what are the types of those jumps.

Results and Discusion

In (Tables 1-4) of the final value of anthropometry, body composition and physical fitness tests, BJ with mean values, SD, minimum and maximum results and the percentage difference between male and female students, Kolgmogorov – Smirnov test normality of distribution of the results. Mutual comparative results in the mentioned tables can find that the reason for the lower score because of female motor abilities and morphologic characteristics all values are usually lower Čuk & Bučar (2000). Drop jump is of high importance in order to achieve sporting performance in both team and individual sports. In (Table 2), in all the jumps men reached higher values than female students. The biggest difference is in the drop jump 80 cm and the percentage of that is 25% in favor of the students, while the smallest difference is the drop jump 20 cm and the percentage is 9% higher value for the benefit of students. In (Table 3), students compared to female students had a greater jump distance of 37 cm, the smaller number of jumps to 9 m, the shorter the time spent during the phase of the rearward leg and arms and for 0.047 s longer resided in the flight phase.

Table 1. *Descriptive statistics Anthropometry, Body composition and Physical fitness tests*

Variables	Female (n=30)				Male (n=37)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Body type (Standard & Athlete)	Standard				Standard			
Height (mm)	1640	60.827	1600	1710	1817.567	61.617	1720	1980
Weight (kg)	61.033	6.153	55	67,3	80.359	9.117	69.1	113
Age (Year)	22	0.733	20	24	21.81	0.844	21	24
Body mass index (kg/m^2)	22.666	1.04	21,5	23,5	24.329	2.484	20	32
Basal metabolic rate (kJ)	6050.666	291.376	5777	6357	8105.108	587.104	7305	10142
Basal metabolic rate (kcal)	1446	69.346	1381	1519	1937.189	140.278	1746	2424
Impedance (Ω)	531.666	47.437	477	562	485.702	50.798	372	598
Fat %	25.1	4.479	21,8	30.2	16.194	3.915	8.9	25
Fat mass (kg)	15.5	4.3	12	20.3	13.259	4.474	6.5	28,3
Fat free mass (kg)	45.533	2.203	43	47	67.1	5.739	57	84.7
Total body water (kg)	33.333	1.594	31.5	34.4	49.124	4.2	41.7	62
Skinfold - triceps (mm)	17	4	13	21	8.837	4.079	4	22
Skinfold - biceps (mm)	14	7.549	7	22	6.378	2.67	3	17
Skinfold - subskapular (mm)	17.666	5.131	12	22	16.459	8.674	8	54
Skinfold - abdominal (mm)	27.333	3,785	23	30	19.702	9.231	7	40
Skinfold - quadriceps f. (mm)	29	6	23	35	22.243	8.712	7	47
Skinfold - triceps (mm)	19.666	4.509	15	24	12	7.568	4	42
Plate tapping in 20 s (freq.)	43.333	4.163	40	48	47.729	4.432	39	57
Leg tapping in 15 s (freq.)	23.333	1.527	22	25	22.918	1.861	19	28
Test sit and reach (cm)	31.666	8.504	23	40	32.567	6.99	12	47
Flamingo balance test (freq.)	9.333	1.154	8	10	9.864	4.54	3	22
Shoulder flexibility (cm)	99.666	13.012	87	113	86.27	10.918	62	110
Sit-ups in 60 sec.(freq.)	35.666	8.962	30	46	33.324	8.086	15	48
Lifting a torso from l. p. max rep. (freq.)	25.333	11.718	12	34	25.081	7.342	14	47
Agility on the ground – bac. (s)	12.91	1.77	11.26	14.78	10.201	1.784	6.71	14.12
Standing jump - Sargent vertical jump (cm)	34	4.582	29	38	50.567	6.304	34	62
Standing broad jump (cm)	168	7.211	160	174	211.108	24.179	177	272
Bent arm hang (s)	10.07	5.837	6.65	16.81	33.996	15.092	8.89	67.24
Medicine ball throwing (3 kg) (cm)	340	10	330	350	566.945	61.726	430	710

Table 2. *Descriptive statistics dropa jumps from 20, 40, 60, 80, 100 cm*

Variables	Female (n=30)				Male (n=37)				F-M
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean %
Drop jump 100 cm	1				1				
Total time (mm:ss)	0.357	0.018	0.337	0.373	0.459	0.6	0.356	0.557	-22.222
Specific energy (J/Kg)	1.54	0.158	1.365	1.672	2.582	0.658	1.523	3.729	-40.356
Total energy (J)	94.588	18.568	75.086	112.055	206.697	52.853	109.661	294.629	-54.238
Drop jump 80 cm	1				1				
Total time (mm:ss)	0.351	0.019	0.338	0.374	0.469	0.06	0.265	0.559	-25.159
Specific energy (J/Kg)	1.489	0.167	1.373	1.681	2.693	0.649	0.844	3.756	-44.708
Total energy (J)	91.404	18.646	77.784	112.656	214.474	49.646	71.754	315.477	57.382
Drop jump 60 cm	1				1				
Total time (mm:ss)	0.378	0.028	0.349	0.405	0.477	0.054	0.361	0.569	-20.754
Specific energy (J/Kg)	1.724	0.254	1.464	1.972	2.775	0.614	1.567	3,892	-37.873
Total energy (J)	106.173	25.789	80.529	132.106	221.384	47.897	133.159	342.924	-52.041
Drop jump 40 cm	1				1				
Total time (mm:ss)	0.378	0.009	0.367	0.386	0.471	0.054	0.336	0.57	-19.745
Specific energy (J/Kg)	1.718	0.089	1.619	1.791	2.705	0.605	1.357	3.906	-36.488
Total energy (J)	104.728	10.552	98.509	116.913	215.718	48.004	124.427	344.143	-51.451
Drop jump 20 cm	1				1				
Total time (mm:ss)	0.418	0.04	0.392	0.465	0.463	0.051	0.344	0.557	-9.719
Specific energy (J/Kg)	2.116	0.418	1.847	2.599	2.61	0.578	1.423	3.729	-18.927
Total energy (J)	130.518	37.992	104.729	174.148	208.442	46.247	122.193	329.654	-37.384

Table 3. *Descriptive statistics of bunny jumps*

Variables	Female (n=30)				Male (n=37)				F-M
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean %
Bunny jump (distance - cm)	104.333	3.511	101	108	141.432	25.182	92	206	-26.231
Bunny jumps - 9m (freq.)	6.333	1.154	5	7	4.945	0.704	4	7	28.068
Bunny jumps - 3m (s)	0.896	0.092	0.82	1	0.788	0.235	0.59	1.9	13.705
Bunny jumps - 6m (s)	2.573	0.136	2.45	2.72	2.024	0.402	1.42	3.8	27.124
Bunny jumps - 9m (s)	3.91	0.174	3.79	4.11	3.18	0.555	2.45	5.42	22.955
Bunny jumps - hand support time (s)	0.36	0.08	0.28	0.44	0.302	0.054	0.24	0.48	19.205
Bunny jumps - legs support time (s)	0.453	0.1	0.36	0.56	0.365	0.098	0.24	0.6	24.109
Bunny jumps - total time flight phase (s)	0.066	0.046	0.04	0.12	0.113	0.094	0.04	0.4	-41.592

Table 4. *Kolmogorov-Smirnov Test*

N=37		DJ100	DJ80	DJ60	DJ40	DJ20	BJD
Normal Parameters[a]	Mean	.459	.469	.477	.471	.463	141.432
	Std. Deviation	.060	.060	.054	.054	.051	25.182
Most Extreme Differences	Absolute	.092	.093	.091	.130	.102	.120
	Positive	.083	.071	.058	.091	.102	.120
	Negative	-.092	-.093	-.091	-.130	-.086	-.072
Kolmogorov-Smirnov Z		.557	.567	.551	.791	.619	.731
Asymp. Sig. (2-tailed)		.916	.905	.922	.558	.838	.659

a. Test distribution is Normal; n=37 male students.
Legend: BJDIS-bunny jump distance, DJ-drop jump.

Table 5. *Pearson's matrix of intercorrelation drop jumps and bunny jump*

Variables	BJDIS	DJ100	DJ80	DJ60	DJ40	DJ20
Bunny Jumps (cm)	1.000	.499	.354	.389	.538	.388
Drop Jump 20 cm		1.000	.719	.776	.750	.715
Drop Jump 40 cm			1.000	.920	.792	.797
Drop Jump 60 cm				1.000	.837	.833
Drop Jump 80 cm					1.000	.790
Drop Jump 100 cm						1.000

Correlation is significant for all at level p <0.01; n=37 male students.
Legend: BJDIS-bunny jump distance, DJ-drop jump.

Table 6. *The regressive analysis of the criteria variable bunny jump*

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.590[a]	.348	.243	21.910	.348	3.310	5	31	.016

a. Predictors: (Constant), DJ-drop jumps from 20, 40, 60, 80, 100 cm.

Reviewing the results (Table 4) of the Kolmogorov-Smirnovog test normality of distribution, it is shown in all variables that distribution of the results does not deviate from the normal distribution of results, which brought to fulfillment of the conditions for further multivariate analysis.

Having inspected and analyzed Pearson's matrix of intercorrelation which is applied on measuring of BJ and DJ (Table 5), it can be observed that the matrix includes coefficients of correlation which have statistically high values on the statistically significant level of (p<0.01). High values can be observed in all inter-correlations of the results. Criterion varaible bunny jump achieved a statistically significant relationship with five variables: drop jump (DJ) from 40 cm (r: 0.538, p<0.01), DJ from 100 cm (r: 0.499, p<0.01), DJ from 60 cm (r: 0.398, p<0.01), DJ 20 cm from (r: 0.388, p<0.01), and DJ from 80 cm (r: 0.354, p<0.01). The bigest correlation is expressed in the drop jump from 40 cm.

Table 7. *Univalent analysis of the variance (ANOVA)*

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7946.259	5	1589.252	3.310	.016[a]
	Residual	14882.822	31	480.091		
	Total	22829.081	36			

a. Predictors: (Constant), DJ-drop jumps from 20, 40, 60, 80, 100 cm.
b. Dependent Variable: BJ-bunny jump – distance (cm).

Regression analysis of the criterion variable bunny jump (BJ) manifest in the area of selected variables (Table 6), does not provide enough information about the effects of the appropriateness of the variables on the success of the performance jump. Common of variance is 59% with the criterion is explained (R Sguare) with the predictor system of variables, while the correlation of the entire system, the predictor variables with the criterion, the coefficient of multiple correlation amounts to 0.34 (RO).

Table 8. *The impact of individual variables on the criteria variable bunny jump*

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	28.933	35.063		.825	.416	-42.578	100.444
	Drop jump 20 cm	146.505	101.465	.350	1.444	.159	-60.434	353.445
	Drop jump 40 cm	-49.740	155.028	-.120	-,.21	.750	-36.921	266.441
	Drop jump 60 cm	-115.088	207.540	-.248	-.555	.583	-538.368	308.192
	Drop jump 80 cm	282.267	132.867	.611	2.124	.042	11.284	553.250
	Drop jump 100 cm	-20.613	136.200	-.042	-.151	.881	-298.395	257.168

Dependent Variable: BJ-bunny jump – distance (cm).

After the insight into the applied univalent analysis of the variance on the sample of (n=37) male students examinees in (Table 7), (ANOVA), we ascertained that the value of the univalent test (F-test; 3.310) so that the contribution of the applied variables is of great significance. However, some important differences between the items were noticed, namely the arithmetic mean and variability. Also, there are significance relations on the statistically important level of the treated variable, (Sig.; .016)

Analyzing the impact of individual variables (Table 8), one can see that the only statistically significant effect on the criterion variable is a variable: DJ from 80 cm which is significant at the level of (Beta: 0.611, sig.<0.05). Significant prediction is just within this variable and this means that the increase in the length of the jump phase of flight time is best defined with this variable. It can be established that it would be best to develop the drop jumps during the training phase of the eccentric reflection of bunny jump forward. From the analysis of the results, no explanation for the phase of flight is found, how long does the motors on the legs last, the angular values during the phase of flight, body weight and height, swing arms in the direction towards engaging to hands in front and these parameters are not included in 66% variance. In future work, it would be required to also take other biomechanical parameters which detremine successful performance. Some authors have conducted similar studies relating to horizonatlne and vertical jumps. Marković (2007) in his research provides training plyometric drop jumps with a statistically significant and practically relevant improvement in vertical jump height with the mean effect ranging from 4.7% (SJ and DJ), over 7.5% (CMJ-fa) to 8.7% (CMJ) a statistically significant and practically relevant improvement in vertical jump height with the mean effect ranging from 4.7% (SJ and DJ), over 7.5% (CMJ-fa) to 8.7% (CMJ). Kyselovičová & Zemková (2010) study of 5 junior gymnasts compares power in the active phase of take off and height of the jump in maximal and during a modified aerobic gymnastics routine. Results showed that subject achieved the highest value in maximal jump (MJ) test, but in combination of high impact aerobics and aerobic jumps (AG II) the examined subjects were able to perform maximal power during the test with only slight decrease about 2%. A group authors Kollias, Panoutsakopoulos, & Papaiakovou (2004) have studied 6 different sports performed DJ from 60 cm on a force plate. Results revealed that volleyball players jumped higher ($p<0.001$) than other athletes because of the fact that they conduct more drop jumps on their practice. However, track and field athletes produced higher peak force and higher power output using a shorter upward phase ($p<0.001$).

Conclusion

Based on the findings of the present study, the following conclusions are drawn. The aim of this study was to investigate the relationship and effect between mechanical output in maxmium vertical and horizontal jumping students 3 year of Faculty of PE and Sport, University of Tuzla. In all drop jumps male students reached higher values than female students. The biggest difference is in the drop jump 80 cm and the percentage of that is 25% in favor of the students, while the smallest difference is the drop jump 20 cm and the percentage is 9% higher value for the benefit of students. Criterion varaible bunny jump achieved the bigest statistically significant relationship with drop jump from 40 cm (r: 0.538, $p<0.01$). The low value of (R Square; 0.34) indicates that the strength of the legs is one of the most important parts of the jump. Strong movement in the direction of movement of the hands forward as part of the kinetic chain certainly is as important in the design and length of the jumps which would be analyzed in future work. Also, the angle of the knee joint and body posture are important in the performance of the bunny jump, but in this work are analyzed and we propose to take into next consideration.

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PhD **Almir ATIKOVIĆ**
Faculty of Physical Education and Sport, Department of Gymnastics, University of Tuzla
Adr.: 2. Oktobra 1, 75000 Tuzla, Bosnia and Herzegovina
Tel/fax.: +387 (0)35 278 536
Mob.: +387 (0)61 830 730
E-mail: almir.atikovic@untz.ba