DOI: 10.7251/SSH1701013B
Original Scientific Paper

UDC: 796.28.063
Originalni naučni rad

Influence of Angular Values of Body Segments on the Distance of the Throw Out In (Z) Axis

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Abstract: This research was carried out on atop atlete, representative of Bosnia and Herzegovina, with the aim of determining the significance and magnitude of the angle value impact (A) of the body segments in the projection (Z) or the sphere length of the sphere 0.1 s before the spit.

When selecting variables, it was taken into account that they satisfy the basic metric characteristics (validity, relievability, objectivity, sensitivity ...) and that they are aligned with the technology and instrumentation used to capture and determine their kinematic parameters. In order to determine the magnitude and size of the influence of kinematic parameters of the individual shot put elements (A) in the projection (Z) or 0.1 s before the ball spout (predictor set of variables) on the length (range) of the sphere (criterion variable), regression analysis was used. The regression results of the analysis indicate that there is a statistically significant influence of the angle position (A) of the body segments in the projection (X) or the length of the sphere 0.1 s before the throw-out.

Analysis of the influence of individual variables of the angular position (A) in the axis (Z), shows that the most statistically positive impact on the criterion variable length in the ejection time of 0.1 seconds before ejection has a variable angular position of the left shoulder of the level of the seventh cervical vertebra (AzLC7R). The time span up to 0.1 seconds before the angular position of the left shoulder to the level of the seventh cervical vertebra to the axis (Z) there is as a result of the angular connection (A) of movement in the vertical extension expressed body axis (Z) relative to the projection of the moment of casting and reconciliation.

Keywords: shot put, rotational technique, kinematics, regression analysis

Uticaj uglovnih vrijednosti segmenata tijela na dužinu izbačaja kugle u projekciji (z) ose

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Sažetak: Istraživanje je provedeno na uzorku vrhunskog bacača kugle, reprezentativca BiH, s ciljem utvrđivanja značajnosti i veličine uticaja uglovnih vrijednosti (A) segmenata tijela u projekciji (z) ose na dužinu izbačaja kugle 0.1 s prije izbačaja. Uzorak varijabli predstavljali su uglovni položaji (A) segmenata tijela snimljeni 0.1 s prije izbačaja kugle, njih dvadeset jedan, koji su činili prediktorski skup varijabli. Prilikom izbora varijabli vodilo se računa da one zadovoljavaju osnovne metrijske karakteristike (validnost, relijabilnost, objektivnost, osjetljivost) i usklađene sa tehnologijom i instrumentarijem koji je korišten prilikom snimanja i utvrđivanja njihovih kinematičkih parametara. Za utvrđivanje značajnosti i veličine uticaja kinematičkih parametara pojedinih segmenata tijela bacača kugle – uglovnih (A) vrijednosti u projekciji (z) ose 0.1 s prije izbačaja kugle (prediktorski skup varijabli) na dužinu izbačaja (domet) kugle (kriterijska varijabla), primjenjena je regresiona analiza. Rezultati regresione analize ukazuju na to da postoji statistički značajan uticaj uglovnog položaja (A) segmenata tijela u projekciji (x) ose na dužinu izbačaja kugle 0.1 s prije izbačaja. Analizom uticaja pojedinačnih varijabli uglovnog položaja (A) u projekciji (z) ose, može se vidjeti da najveći i statistički značajan pozitivan uticaj na kriterijsku varijablu, dužina izbačaja u vremenu 0,1 s prije izbačaja ima varijabla, *uglovni položaj lijevog ramena u nivou sedmog vratnog pršljena (AzLC7R)*. U trenutka izbačaja do 0.1 s prije ugaonog položaja lijevog ramena u nivou sedmog vratnog pršljena u osi (z) došlo je kao posljedica povezanosti uglovnog (A) kretanja u vertikalnom opružanju tijela ose (z) u odnosu na projekciju kretanja sprave odnosno trenutka izbačaja.

Ključne riječi: bacanje kugle, rotaciona tehnika, kinematika, regresiona analiza

Introduction

Shot put rotational technique is characterized by very complex structure of the movement to be performed with high speed and to a limited area of the lot. For easier analysis of technique, training techniques and the purpose of scientific research, shot put rotational technique is divided into four phases, while biomechanical analysis can be divided into seven phases, but it is complete so that in its implementation the transition from phase to phase is not notice. Due to the large angular deviation during movement, ie. any errors that occur in one phase, can have possible manifestation on the proper execution of movements of the body in the next phase and after casting balls, which calls into question the achievement of the maximum range casting.

Kinematic analysis aimes to describe and quantify linear and angular displacement between the launchers body segments or movements in relation to the environment and to calculate the velocity and acceleration. Determination of distance traveled, position and movement of the body or body parts and certain segments of the body is achieved by identifying markers positioned on the characteristic anatomical points. Kinematics based on 2D and 3D reconstruction is increasingly present in sports, sports prophylaxis and rehabilitation.

Evaluating of the success of shot put throw is simple, because the length of the throw is only result which is evaluated and graded. The length is most dependent on the way in which the forces acts on the ball, which is related to the speed of ejection, corner of ejection and the amount of ejection (Stepanek & Sušanka, 1987; Palm, 1990; Gemer, 1990; Bartonietz, 1994; Goldman et. Al., 1997; Luhtanen et. al., 1997; Goldman et. al., 1997; Lanka, 2000; Hubbard et. al., 2001, Linthorne., 2001; Rasmussen, 2005).

The complexity of the shot put rotational technique stems from 3D - dimensional movement of the shot-putter from limited space and a short period of timing.

Due to the complexity of movement that produces a force acting on the ball, limited space and short time, analyzing these disciplines is a very complex task for trainers, experts and academics. From the above, in this paper, emerged a short timing or ejections 0.1 seconds prior to casting and change of values in the cast 0.1 seconds before casting.

The objective of this study to determine the effect of specific angular value of the body segment length of the projection of the ejection balls in (Z) axis.

Uvod

Rotacionu tehniku bacanja kugle karakterišu veoma kompleksne strukture kretanja koje se izvode sa velikom brzinom i pravilima definisanom prostoru. Radi lakše analize tehnike, usavršavanja tehnike i u svrsi naučnog istraživanja, rotaciona tehnika bacanja kugle podijeljena je u četiri faze, a u biomehaničkoj analizi može se podijeliti na sedam faza, ali ipak ona je cjelovita tako da se kod njenog izvođenja ne primjećuje prelaz iz faze u fazu. Zbog velikog uglovnog odstupanja prilikom kretanja, tj. eventualne greške koja nastane u jednoj fazi, moguće je ispoljavanje njenog uticaja na pravilno izvođenje kretanja tijela u sljedećoj fazi i poslije izbačaja kugle, što dovodi u pitanje postizanje maksimalnog dometa izbačaja.

Kinematska analiza odnosi se na opisivanje i kvantifikovanje linearnog i ugaonog pomaka između segmenata tijela bacača ili kretanja u odnosu na okolinu kao i izračunavanje brzine i ubrzanja. Određivanje prijeđenog puta, položaja i pokreta tijela ili dijelova tijela i pojedinih segmenata tijela ostvaruje se identifikacijom markera pozicioniranim na karakterističnim anatomskim tačkama. Kinematika bazirana na 2D i 3D rekonstrukciji sve više je prisutna u sportu, sportskoj profilaksi i rehabilitaciji.

Ocjenjivanje uspješnosti bacanja kugle veoma je jednostavno, jer je dužina bacanja jedini rezultat koji se vrednuje i boduje. Dužina je najviše zavisna od puta na kojem sile djeluju na kuglu, što se manifestuje u brzini izbacivanja, uglu izbacivanja i visini izbacivanja (Stepanek & Sušanka, 1987; Palm, 1990; Gemer, 1990; Bartonietz, 1994; Goldman et. al.,1997; Luhtanen et. al., 1997; Goldman et. al., 1997; Lanka, 2000; Hubbard et. al., 2001; Rasmussen, 2005).

Kompleksnost bacanja kugle rotacionom tehnikom proističe iz 3D – dimenzionalnog kretanja bacača kugle iz ograničenog prostora i kratkog vremenskog tajminga.

Zbog kompleksnosti kretanja koji proizvode silu djelovanja na kuglu, ograničenosti prostora i kratkog vremena, analiziranje ove atletske discipline predstavlja vrlo složen zadatak za trenere, stručnjake i naučne radnike. Iz navedenog je u ovom radu i proizašlo kratko vrijeme trenutka izbačaja 0.1 sekunde prije izbačaja i promjena vrijednosti uglobnih veličina segmenata tijela kod izbačaja 0.1 sekunde prije izbačaja.

Metod rada

Uzorak ispitanika

Istraživanje je provedeno na uzorku vrhunskog bacača kugle, bosansko-hercegovačkom državnom reprezentativcu u bacanju kugle sa ličnim rekordom od 20.73 m.

Methods

The sample

This research was carried out on a top shot put athlete, member of the national team with a personal record of 20.73 m. The examinee is Hamza Alić, 27 years old; height 1.95 m; weight 129.5 kg; a representative of Bosnia and Herzegovina national team, a silver medalist at the European Championship, participant of Olympic Games, World Championships, Mediterranean Games, Balkan Games and many other domestic and international competitions.

The sample of variables

When selecting variables that should enable achieving the objective research, we took into account that they meet basic metric characteristics: validity, reliability, objectivity, sensitivity, discrimination, standardization, economics etc. The selection of variables is aligned with a specific sample of respondent and that is conditioned by sensors mounted to a segment of the body of subjects when shooting. For the determination of kinematic parameters software with three-dimensional recording with the help of synchronized cameras (Sony DVCAM DSR-300 PK) and (Sony TRV840) was used.

To estimate the kinematic parameters four parameters: the distance traveled (S), velocity (V), the angle (A) and angular velocity (w) were applied.

To determine the kinematic parameters, the acceleration of the individual body segments (A) of the shot putter in the projection of (Z) axis, the following variables were applied:

1. L5 lumbal vertebra and S1 sacral region.....AzL5S1
2. L4L3 lumbar vertebrae.....AzL4L3
3. T9T8 thoracic vertebrae .....Az T9T8
4. T1 thoracic vertebra and C7 cervical vertebra AzT1C7
5. C1 cervical vertebra and head AzC1GL
6. The right cervical vertebra C7 and shoulder AzDC7R
7. Right shoulder ..... AZDR
8. Right elbow ..... AzDLAK
9. Right wrist .....AzDRZG
10. Left C7 cervical vertebra and the shoulder AzLC7R
11. left shoulder.....AzLRAM
12. Left-elbow .....AzLLAK
13. Left wrist ..... AzLRZG
14. Right hip.....AzDKUK
15. Right knee .....AzDKLJ
16. Right ankle ..... AzDNZG
17. Right foot..... AzDSTO
18. Left hip ..... AzLKUK
19. Left knee..... AzLKLJ
20. Left ankle.....AzLNZG
21. Left foot.....AzLSTO

Ispitanik je Hamza Alić, star 27 godina; visina 1.95 m; težina 129.5 kg; reprezentativac Bosne i Hercegovine, osvajač srebrne medalje na dvoranskom prvenstvu Evrope, učesnik Olimpijskih igara, Svjetskog prvenstva, Mediteranskih igara, Balkanskih igara i mnogih drugih domaćih i međunarodnih takmičenja.

Uzorak varijabli

Prilikom izbora varijabli koje treba da omogućite ostvarenje postavljenog cilja istraživanja, vodilo se računa da one zadovoljavaju osnovne metrijske karakteristike: validnost, pouzdanost, objektivnost, osjetljivost, diskriminativnost, standardizovanost, ekonomičnost. Izbor varijabli je usklađen sa uzorkom ispitanika koji je u ovom istraživanju specifičan i koji je uslovljen postavljenim senzorima na pojedine segmente tijela ispitanika prilikom snimanja. Za utvrđivanje kinematičkih parametara korišten je softver sa trodimenzionalnim snimanjem uz pomoć sinhronizovanih kamera (SONY DVCAM DSR-300 PK) i (SONY TRV840E).

Prediktorski skup varijabli

Za procjenu kinematičkih parametara primijenjena su četiri parametra: prijeđeni put (S), brzina (V), ugao (A) i ugaona brzina (w).

Za utvrđivanje kinematičkih parametara, uglovne vrijednosti (A) pojedinih segmenata tijela bacača kugle u projekciji (z) ose, primijenjene su sljedeće varijable:

1. L5 lumbalni pršljen i S1 krsni region.....AzL5S1
2. L4L3 lumbalni pršljenovi.....AzL4L3
3. T9T8 grudni pršljenovi.....Az T9T8
4. T1 grudni pršljen i C7 vratni pršljen AzT1C7
5. C1 vratni pršljen i glava AzC1GL
6. Desni C7 vratni pršljen i rame..... AzDC7R
7. Desno rame..... AzDRAM
8. Desni lakat..... AzDLAK
9. Desni ručni zglob .....AzDRZG
10. Lijevi C7 vratni pršljen i rame AzLC7R
11. Lijevo rame .....AzLRAM
12. Lijevi lakat.....AzLLAK
13. Lijevi ručni zglob ..... AzLRZG
14. Desni kuk.....AzDKUK
15. Desno koljeno.....AzDKLJ
16. Desni nožni zglob..... AzDNZG
17. Desno stopalo ..... AzDSTO
18. Lijevi kuk ..... AzLKUK
19. Lijevo koljeno ..... AzLKLJ
20. Lijevi nožni zglob.....AzLNZG
21. Lijevo stopalo.....AzLSTO

Criterion set of variables

The criterion variable for estimating the kinematic parameters of the ball pitcher is the length of the throw (range) (36 correct legal throws).

Conditions and measurement techniques

The recording and measurement of the rotational technique of the examinee, member of the of Bosnia and Herzegovina national team was conducted in September 2011 in the competition phase (achievement of the Olympic Standards) and the preparation phase for the Olympic Games in London in 2012.

Recording was done on the "Šiška" stadium in Ljubljana and at the city stadium in Kranj. Shot put circle diameter of 2,135 m, with segments and gauged metal meter according to IAAF standards was used. The terrain and weather conditions for the test were extraordinary. For testing, 85 shots were taken. Field and time conditions were favorable for testing. The test recoreded 85 throws.

The athlete throws the ball with the right hand. In the final analysis 36 legal shots were taken into account. Recording was done with two synchronized cameras (Sony DVCAM DSR-300 PK) placed at an angle of 90 ° to their optical axis. The third camera (Sony TRV840) is set at a height of 4 m directly above the center circle for throwing (Figure 1 and 2).

Analyzed space circle was calibrated with the reference frame dimensions 1m x 1m x 2m, while eight reference edges were taken as calibration points (Figure 2). Length of the analyzed movement is defined by (X) axis, the height by (Y) axis, and depth by (Z) axis. For the determination of the kinematic parameters of the techniques 3-D softwer APAS (Ariel Dynamics Inc., San Diego, Ca) was used.

Digitalisation of the 15-segment model of body launcher which we defined with 18 reference points, was conducted. Eighteenth point was defined with the center of the sphere. Segments of the models show parts of the body associated with dotted joints. Mass and center of gravity segments as well as the center of gravity of the body were calculated on the basis of antropometric model (Dempster, 1955). Coordinates of physical point were smoothened with the seventh degree Buterworth digital filter. Information on path (S), velocity (V), A-corner (A), w-angular speed (w) in the X, Y and Z axes were obtained with the software package ARIEL.

Kriterijski skup varijabli

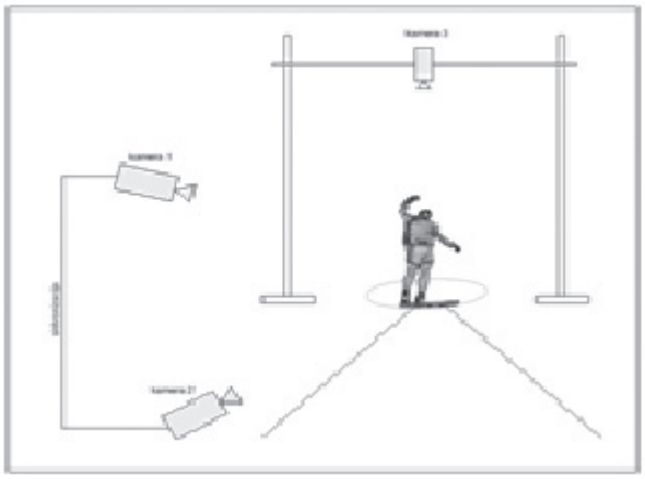
Kriterijske varijable za procjenu kinematičkih parametara bacača kugle čine dužine izbačaja (domet) kugle tretiranih 36 ispravnih hitaca.

Uslovi i tehnike mjerenja

Snimanje i mjerenje rotacione tehnike bacanja kugle kod ispitanika - člana reprezentacije Bosne i Hercegovine izvedeno je u mjesecu septembru 2011. godine u takmičarskoj fazi (postizanje olimpijske norme) i fazi priprema za Olimpijske igre u Londonu 2012. godine. Snimanje je obavljeno na stadionu „Šiška" u Ljubljani i na gradskom stadionu u Kranju. Korišten je krug za bacanje kugle prečnika 2.135m, sa segmentom i baždarenim metalnim metrom prema standardima IAAF. Teren i vremenski uslovi za testiranje bili su povoljni za realizaciju testiranja. Testiranje je provedeno u prijepodnevnim časovima. Na testiranju je snimljeno 85 hitaca - izbačaja. Atletičar baca kuglu sa desnom rukom. Kod konačne obrade podataka analizirano je 36 ispravnih hitaca. Snimanje je obavljeno sa dvije sinhronizovane kamere (SONY DVCAM DSR-300 PK) stavljene pod uglom 90° na njihovu optičku osovinu. Treća kamera (SONY TR-V840E) postavljena je na visini 4 m tačno iznad centra kruga za bacanje (Šematski prikaz 1 i slika 2).

Analizirani prostor kruga bio je kalibriran sa referentnim okvirom dimenzije 1m x 1m x 2m, a pri tome je za kalibriranje uzeto osam referentnih rubova (slika 2). Dužina analiziranog kretanja definisana je sa (X) osom, visina sa (Y) osom i dubina sa (Z) osom. Za determinisanje kinematičnih parametara tehnike upotrijebljen je 3-D softwer APAS (Ariel Dynamics Inc., San Diego, Ca).

Obavljena je digitalizacija 15-segmentnog modela tijela bacača definisanih sa 18 referentnih tačaka. Osamnaesta tačka bila je definisana sa centrom kugle. Segmenti modela prikazuju dijelove tijela povezane sa tačkastim zglobovima. Mase i centri gravitacije segmenata kao i centar gravitacije tijela izračunati su na osnovi antropometričnog modela (Dempster,1955). Koordinate tjelesnih tački izglađene su sa digitalnim Buterworthovim filtrom 7. stepena. Sa programskim paketom ARlEL dobijeni su podaci o putu (S), brzini (V), A-uglu (A) , w-ugaonoj brzini (w) u X, Y i Z osi.



Šematski prikaz 1. *Raspored postavljenih kamera*
Sheme 1. *Schedule of set cameras*

Slika 1. *Kamera za snimanje (SONY TRV840E)*
Figure 1. *Recording camera (SONY TRV840E)*

Methods of data processing

In order to determine the impact of predictor values of kinematic parameters of individual body segments shot putters - angular A value in the Z axis at the time of casting (predictor set of variables) of the length of range (criterion variable), regression analysis was applied.

Results and Discussion

Regression analysis of the criterion variable type of the length of ejections was based on variable angular value (A) in (z) axes 0.1 seconds before casting is shown in Table 1.

Table 1. *Regression analysis of the criterion variable of the throw disatnce in the manifest space of the angle value variables (A) of the body segments in the projection (z) axis or 0.1 s before the throw-out*

Metode obrade podataka

Za utvrđivanje značajnosti i veličine uticaja kinematičkih parametara pojedinih segmenata tijela bacača kugle – uglovnih A vrijednosti u projekciji (Z) ose u trenutku izbačaja (prediktorski skup varijabli) na dužinu dometa kugle (kriterijska varijabla), primijenjena je regresiona analiza.

Rezultati i diskusija

Regresiona analiza kriterijske varjable dužine izbačaja na osnovu varijabli uglovnih vrijednosti (A) u projekciji (Z) ose 0.1 s prije izbačaja prikazana je u tabeli 1.

Tabela 1. *Regresiona analiza kriterijske varijable dužina izbačaja kugle u manifestnom prostoru varijabli uglovnih vrijednosti (A) segmenata tijela u projekciji (Z) ose 0.1 s prije izbačaja*

Model Summary

Model		R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
dimension	1	.887[a]	.786	.466	.26389	786	2.454	21	14	.044

a. Predictors: (Constant), AzLSTO, AzDC7R, AzDRZG, AzL4L3, AzDKLJ, AzC1GL, AzLNZG, AzLLAK, AzLRZG, AzDSTO, AzLRAM, AzLKUK, AzLC7R, AzDRAM, AzLKLJ, AzL5S1, AzDLAK, AzDKUK, AzDNZG, AzT9T8, AzT1C7

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.589	21	.171	2.454	.044[a]
	Residual	.975	14	.070		
	Total	4.564	35			

a. Predictors: (Constant), AzLSTO, AzDC7R, AzDRZG, AzL4L3, AzDKLJ, AzC1GL, AzLNZG, AzLLAK, AzLRZG, AzDSTO, AzLRAM, AzLKUK, AzLC7R, AzDRAM, AzLKLJ, AzL5S1, AzDLAK, AzDKUK, AzDNZG, AzT9T8, AzT1C7
b. Dependent Variable: Dužina

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	40.779	21.797		1.871	.082			
	AzL5S1	-.137	.044	-2.165	-3.092	.008	-.019	-.637	-.382
	AzL4L3	1.156	.794	2.143	1.456	.167	-.007	.363	.180
	AzT9T8	-.306	.267	-1.787	-1.148	.270	-.053	-.293	-.142
	AzT1C7	-.845	.896	-2.445	-.942	.362	.333	-.244	-.116
	AzC1GL	.910	.795	2.894	1.144	.272	.322	.292	.141
	AzDC7R	-.090	.064	-.793	-1.406	.182	-.214	-.352	-.174
	AzDRAM	-.007	.007	-.434	-1.021	.325	-.137	-.263	-.126
	AzDLAK	.025	.016	1.391	1.533	.148	-.095	.379	.189
	AzDRZG	.000	.006	.032	.082	.936	-.022	.022	.010
	AzLC7R	.157	.069	.772	2.295	.038	.164	.523	.283
	AzLRAM	.040	.028	.617	1.460	.166	-.052	.363	.180
	AzLLAK	-.047	.031	-.477	-1.510	.153	-.134	-.374	-.187
	AzLRZG	.001	.011	.023	.079	.938	.351	.021	.010
	AzDKUK	.048	.038	1.256	1.269	.225	.116	.321	.157
	AzDKLJ	-.013	.027	-.439	-.462	.651	-.002	-.123	-.057
	AzDNZG	-.027	.032	-.920	-.849	.410	-.102	-.221	-.105
	AzDSTO	.008	.031	.254	.267	.794	-.124	.071	.033
	AzLKUK	-.041	.041	-.514	-.999	.335	.137	-.258	-.123
	AzLKLJ	.042	.027	1.195	1.563	.140	.146	.385	.193
	AzLNZG	-.003	.018	-.080	-.166	.870	.336	-.044	-.021
	AzLSTO	-.005	.013	-.072	-.352	.730	.003	-.094	-.044

a. Dependent Variable: Dužina / *Length*

Legenda / Legend: *Multiple R - koeficjent multiple korelacije; R Squore - kvadrat koeficjenta multiple korelacije; T – test - test vrijednosti značajnosti regresijskih koeficjenata; SIG-T značajnost koeficjenta parcijalne regresije, df1 i df2 stepeni slobode; F - uobičajni F-test za testiranje značajnosti koeficjenata multiple 2 korelacije; Signif F - nivo statističke značajnosti koeficijenta multiple korelacije i Standard Error - standardna greška rezultata u kriterijskoj varijabli.*

By analyzing the parameters of the regression analysis of the predictive system of the angular values of the individual body segments in the projection (Z) axis 0.1 seconds before the throw out with the criterion variable of the ball throwing length (Table 1) it is apparent that the coefficient of multiple correlation is R = .88 with the coefficient of determination of R Squere = .78. On the basis of the obtained results it can be concluded that in the explanation of the general influence of predictors on the criterion satisfies a high proportion of isolated variance, while the remaining part of the 22% variance of the waste falls on other segments not used in this assay.

Further analysis can be accessed, because the conditions met statistical significance level of p <.05, partial impact predictor system angular values of individual body segments in the (Z) axis at the moment of casting with criteria variable length shot put.

Statistically significant Beta coefficients at the level

Analizom parametara regresione analize prediktorskog sistema uglovnih vrijednosti pojedinih segmenata tijela u projekciji (Z) ose 0.1 s prije izbačaja sa kriterijskom varijablom dužina bacanja kugle (tabela 1) vidljivo je da koeficijent multiple korelacije iznosi R=.88 sa koeficijentom determinacije od R Squere =.78. Na osnovu dobijenih rezultata može se konstatovati da u objašnjenju generalnog uticaja prediktora na kriterij zadovoljava visok udio izolovane varijanse (78%), dok preostali dio varijanse od 22 % otpada na druge segmente koji u ovom israživanju nisu primijenjeni.

Daljem analiziranju se može pristupiti, jer su ispunjeni uslovi statističke značajnosti na nivou od p< .05 parcijalnog uticaja prediktorskog sistema uglovnih vrijednosti pojedinih segmenata tijela u (z) osi u trenutku izbačaja sa kriterijskom varijablom dužina bacanja kugle.

Statistički značajane Beta koeficijente na nivou p<.01 ima uglovna vrijednost varijable *L5 lumbalni pr-*

of p <.01 has angular value of the variable *lumbar vertebra L5 and S1 sacral region - AzL5S1* (Beta = -2.16), whose projections on the criterion variable have a negative sign. The value of the angle to the *left shoulder and C7 cervical vertebra - AzLC7R* (beta = .77), had statistically significant individual impact on the level of p <.05 whose projections on the criterion variable were with a positive sign. No variable had negative impact on the projections of individual criterion variable with statistical significance P <.05.

Thus, it can be concluded that less value angles in variable *L5 lumbar vertebra and S1 sacral region* (AzL5S1), which lead to the fulfillment of 0.1 seconds before casting contribute to greater lenght shots as criterion variables. Angular positions of body segments 0.1 seconds before casting occurs as a result of active angular (A) movement predictor modeled kinematic variables in the axis (Z). From the analysis of the influence of individual variables angular position (A) in the z axis (Table 2), it can be noticed that the largest contribution to the criterion variable length in the range of 0.1 seconds before the moment of casting has a variable *lumbar vertebra L5 and S1 sacral region*. At a time of 0.1 seconds prior to the time span up to the angular position L5 lumbar vertebrae and S1 sacral region in the axis (Z) came as a result of the delayed angular connection (A) of movement in the vertical extension expressed bodies along the axis relative to the projection of reconciliation to time casting . Therefore we can say that the greater length shots realized when the pitcher has less fluctuations in the vertical extension expressed bodies and tilting back and forth when performing these technique.

Also, it can be concluded that the increase of corners left shoulder in the level of the seventh cervical vertebra exercised influence on the length of realized results in the shot put. 0.1 seconds before the moment of ejection occurs as a result of active angular (A) movement predictor modeled kinematic variables in the z axis. From the analysis of the influence of individual variables angular position (A) in the axis (Z) (Table 1), we conclude that the largest and statistically positive impact on the criterion variable length in the range of 0.1 seconds before the moment of casting has a variable *angular position of the left shoulder level seventh cervical vertebra* (AzLC7R .038). Range of throws (competitive result) is defined by the length of effect offorce on the ball, which is affected by the speed ejection (eng. release velocity), the angle of ejection (eng. angle of release) and the amount of ejection (eng. height of release) (Stepanek & Sušanka, 1987; Palm, 1990; Gemer, 1990; Bartonietz, 1994; Oesterreich et. al., 1997; Luhtanen et. al., 1997; Lanka, 2000; Hubbard et. al., 2001; Linthorne, 2001; CoH and

šljen i S1 krsni region – AzL5S1 (Beta = -2.16), čije su projekcije na kriterijsku varijablu sa negativnim predznakom. Statistički značajan pojedinačni uticaj na nivou p<.05 imaju vrijednosti ugla lijevo rame i C7 vratni pršljen – AzLC7R (Beta = .77), čije su projekcije na kriterijsku varijablu sa pozitivnim predznakom. Negativne projekcije pojedinačnog uticaja na kriterijsku varijablu sa statističkom značajnošću p < .05 nema niti jedna varijabla.

Dakle, može se konstatovati da manje vrijednosti uglova u varijabli *L5 lumbalni pršljen i S1 krsni region (AzL5S1)*, koji su ostvareni 0,1 s prije izbačaja doprinose većoj dužini hica kao kriterijskoj varijabli. Uglovni položaji segmenata tijela 0,1 s prije izbačaja se dešava kao posljedica aktivnog uglovnog (A) kretanja prediktorskih modelovanih kinematičkih varijabli u osi (Z). Analizom uticaja pojedinačnih varijabli uglovnog položaja (A) u osi Z (tabela 2), može se vidjeti da najveći doprinos na kriterijsku varijablu dužina dometa u 0.1 sekunde prije trenutka izbačaja ima varijabla, *L5 lumbalni pršljen i S1 krsni region*. U vremenu 0.1 s prije trenutka izbačaja do ugaonog položaja L5 lumbalnog pršljena i S1 krsnog regiona u osi (Z) došlo je kao posljedica povezanosti zakašnjelog uglovnog (A) kretanja u vertikalnom opružanju tijela u Z osi u odnosu na projekciju kretanja sprave prema trenutku izbačaja. Shodno tome može se reći da su veće dužine hica ostvarene onda kada bacač ima manje oscilacije u vertikalnom opružanju tijela i naginjanju naprijed-nazad prilikom izvođenja tehnike.

Takođe, može se zaključiti da se sa povećanjem uglova lijevog ramena u nivou sedmog vratnog pršljena ostvaruje uticaj na dužina ostvarenog rezultata u bacanju kugle. 0.1 s prije trenutka izbačaja se dešava kao posljedica aktivnog uglovnog (A) kretanja prediktorskih modelovanih kinematičkih varijabli u projekcij (Z) ose. Analizom uticaja pojedinačnih varijabli uglovnog položaja (A) u osi (Z) (tabela 1), može se vidjeti da najveći i statistički pozitivan uticaj na kriterijsku varijablu dužina dometa u 0.1 s prije trenutka izbačaja ima varijabla, uglovni položaj *lijevog ramena u nivou sedmog vratnog pršljena (AzLC7R .038)*. Domet bacanja (rezultat takmičenja) definisana je dužinom puta djelovanja sile na kuglu, na koju utiču brzina izbacivanja (eng. release velocity), ugao izbacivanja (eng. angle of release) i visina izbacivanja (ang. height of release) (Stepanek & Sušanka, 1987; Palm, 1990; Gemer, 1990; Bartonietz, 1994; Oesterreich et. al., 1997; Luhtanen et. al., 1997; Lanka, 2000; Hubbard et. al., 2001; Mikić & Biberović, 2001; Čoh i Štuhec, 2008). U vremenu 0.1 sekunde prije trenutka izbačaja do ugaonog položaja lijevog ramena u nivou

Gall, 2008). At 0.1 seconds before the moment of casting to the angular position of the left shoulder to the level of the seventh cervical vertebra in the z axis came as a result of the angular connection (A) of movement in the vertical axis of the body extension expressed in relation to the projection of reconciliation or point ejections.

In analyzing the results of the regression analysis predictor system of variables angular position values of individual body segments (A) in (Z) axes 0.1 seconds before casting, which predictor system of variables contribute to the impact of the treated criterion variable of this study, it can be concluded that the length of the casting balls depend on the angular position (A) of individual body segments in a particular projection of X, Y and Z axis, 0.1 seconds before the ejection, which confirms a statistically significant effect of predictors on the criterion with axes, while they have not been confirmed by X and (Y) axis.

Conclusion

Based on the results of the regression analysis of the angle values (A) of the body segments observed for 0.1 seconds prior to the discharge of the device (balls) it can be concluded that the angular values in the projection (Z) axis have the most significant prediction values on the distance.

Results of regression analysis showed that increasing the angle of the left shoulder to the level of the seventh cervical vertebra has a statistically significant impact on the length of the result achieved in the shot put 0.1 seconds before the moment of casting that occurs as a result of active angular (A) movement predictor modeled kinematic variables in the axis (Z). The analysis of the influence of individual variables angular position (A) to the axis (Z), shows that the largest and statistically positive impact on the criterion variable length in the range of 0.1 seconds before casting has a variable angular position of the left shoulder to the level of the seventh cervical vertebra (AzLC7R). The time span up to 0.1 seconds before the angular position of the left shoulder to the level of the seventh cervical vertebra to the axis (Z) there is as a result of the angular connection (A) of movement in the vertical extension expressed body axis (Z) relative to the projection of the moment of casting and reconciliation. Analysis of the results of the regression analysis predictor system of variables angular position values of individual body segments (A) to (Z) axes 0.1 seconds before casting, which predictor system of variables contribute to the impact of the treated criterion variable of this study shows that the length of the casting balls depends of the angular position (A) of particular segments of the body in each projection (X), (Y) and (Z) axes 0.1 seconds before sedmog vratnog pršljena u osi (Z) došlo je kao posljedica povezanosti uglovnog (A) kretanja u vertikalnom opružanju tijela ose Z u odnosu na projekciju kretanja sprave odnosno trenutka izbačaja.

U analizi rezultata regresione analize prediktorskog sistema varijabli uglovnih vrijednosti položaja pojedinih segmenata tijela (A) u (Z) osi 0.1 s prije izbačaja, koji prediktorskim sistemom varijabli doprinose uticaj na tretiranu kriterijsku varijablu ovog istraživanja, može se zaključiti da će dužina izbačaja kugle zavisiti od uglovnog položaja (A) pojedinih segmenata tijela u pojedinoj projekciji X, Y i Z osi, 0.1 s prije izbačaja, čime je potvrđen statistički značajan uticaj prediktora na kriterij u projekciji (Z) ose, dok ista nije potvrđena za (X) i (Y) osu.

Zaključak

Na osnovu rezultata regresione analize uglovnih vrijednosti (A) praćenih segmenata tijela 0.1 s prije izbačaja kugle može se zaključiti da najznačajnije prediktorske vrijednosti na dužinu izbačaja imaju uglovne vrijednosti u projekciji (Z) ose. Rezultati regresione analize pokazuju da povećanje ugla lijevog ramena u nivou sedmog vratnog pršljena ima statistički značajan uticaj na dužina ostvarenog rezultata u bacanju kugle 0,1 s prije trenutka izbačaja koji se dešava kao posljedica aktivnog uglovnog (A) kretanja prediktorskih modelovanih kinematičkih varijabli u projekciji (Z) ose. Analizom uticaja pojedinačnih varijabli uglovnog položaja (A) u projekciji (Z) ose, može se vidjeti da najveći i statistički pozitivan uticaj na dužina dometa u 0.1 s prije izbačaja (kriterijska varijabla) ima varijabla, *uglovni položaj lijevog ramena u nivou sedmog vratnog pršljena (AzLC7R)*. U trenutka izbačaja do 0.1 s prije ugaonog položaja lijevog ramena u nivou sedmog vratnog pršljena u projekciji (Z) ose došlo je kao posljedica povezanosti uglovnog (A) kretanja u vertikalnom opružanju tijela ose (Z) u odnosu na projekciju kretanja sprave odnosno trenutka izbačaja. U analizi rezultata regresione analize prediktorskog sistema varijabli uglovnih vrijednosti položaja pojedinih segmenata tijela (A) u projekciji (Z) ose 0.1 s prije izbačaja, koji prediktorskim sistemom varijabli doprinose uticaju na tretiranu kriterijsku varijablu ovog istraživanja, može se zaključiti da dužina izbačaja kugle zavisi od uglovnog položaja (A) pojedinih segmenata tijela u pojedinoj projekciji (X), (Y) i (Z) ose 0.1 s prije izbačaja, čime je potvrđen statistički značajan uticaj prediktora na kriterij u projekciji (Z) ose, dok ista nije potvrđena za (X) i (Y) osu.

Dobijeni rezultati istraživanja mogu imati svoju praktičnu vrijednost i primjenljivost u procesu progra-

casting, which confirms a statistically significant effect of predictors on the criteria in (the) axis, while the same is not confirmed for (X) and (Y) axis.

The results of this research can have practical value and applicability in the process of programming the training of the ball pitchers in order to objectively evaluate and improve the performance of the ball throwing technique as well as identify the remaining athletes' potential to improve sport achievements.

Authorship statement
The authors have contributed equally.

Financial disclosure
We declare that we have no confl icts of interest.

miranja trenažnog rada bacača kugle u cilju objektivnog procjenjivanja i usavršavanja izvođenja tehnike bacanja kugle kao i identifikacija preostalih potencijala sportiste za poboljšanje sportskih dostignuća.

Izjava autora
Autori pridonijeli jednako.

Konflikt interesa
Mi izjavljujemo da nemamo konflikt interesa.

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Primljen: 25.mart 2017. / Received: March 25, 2017
Prihvaćen: 10. april 2017. / Accepted: April 10, 2017