Originalni naučni rad

RAZLIKE U BRZINI ŠUTA IZMEĐU POZICIJA ŠUTA U VRHUNSKOM RUKOMETU^{1 2}

UDK: 796.322.012.574

DOI: 10.5937/snp2102077F

Nikola Foretić

Kineziološki fakultet, Sveučilište u Splitu, Hrvatska

Vladimir Pavlinović³

Kineziološki fakultet, Sveučilište u Splitu, Hrvatska

Šime Veršić

Kineziološki fakultet, Sveučilište u Splitu, Hrvatska

Apstrakt: Brzina šuta jedna je od najznačajnijih sposobnosti koje imaju utjecaj za uspjeh u vrhunskom rukometu. Stoga je glavni cilj istraživanja bio utvrditi razlike između brzine šuta na različitim pozicijama šuta u vrhunskom rukometu. Ukupno su analizirana 784 šuta. Brzina šuta mjerena je iBall sustavom (SELECT) koji ima ugrađen čip za praćenje brzine lopte, pozicije šuta i pozicije lopte u realnom vremenu na utakmici. Pozicija šuta definirana je kao geometrijska pozicija i taktička situacija iz koje je izveden udarac na gol. Razlike između pozicija šuta utvrđene su Kruskal-Wallisovim testom. Značajne razlike utvrđene su između pozicija šutiranja ($\chi^2=95,83$). Post-hoc analiza je pokazala kako su udarci upućeni izvan linije 9 metara značajno brži od onih upućenih sa drugih pozicija. Šutovi izvan 9 metara zahtijevaju najbržu izvedbu s obzirom na to da se igrači ne mogu nadmudrivati sa vratarom, kao iz nekih drugih pozicija šuta. Modificirani „spori“ šutovi (npr. „suhi list“ ili lob) upotrebljavaju se iz pozicija kada je igrač bliže голу; iz kontranapada, iz prolaza ili iz sedmerca. U ovim pozicijama/situacijama igrači imaju zahtjevniji kut šuta tijekom kojeg brzina leta lopte nije uvijek prednost u izvedbi udarca.

Ključne reči: brzina šuta, brzina lopte, profesionalni rukomet, bacanje, timski sport

UVOD

Bacanje se smatra osnovnim oblikom kretanja i spada u fundamentalne motoričke sposobnosti. Izvođenje bacanja je vrlo prirodno pa ga sportaši nauče u vrlo ranim fazama sportskog razvoja (Bompa, 1996; Raudsepp & Päll, 2006). Kao takvo, pokret bacanja prisutan je u velikom broju timskih sportova s loptom. Također, pojavljuje se u različitim sportskim tehnikama u kojima sportaši moraju postići pogodak rukom. U nekim sportovima postizanje pogotka orijentirano je na ciljanje i gađenje (npr. košarka ili ragbi), dok je u nekim drugim, bacanje više pod utjecajem eksplozivnosti i jakosti (npr. vaterpolo ili američki nogomet).

Rukomet pripada grupi sportova u kojima bacanje mora biti izvedeno što je moguće eksplozivnije, a da se ne izgubi preciznost. Kontrola lopte postiže se veličinom lopte (obujmom i masom) i specijalnim ljepljivom koje pomaže igračima u manipulaciji lopte i izvedbi specifičnih šutova (npr. šutovi s rotacijom). S obzirom na to da je

¹ Rad primljen: 28.4.2021, prihvaćen za objavljivanje: 10.6.2021.

² Rad je u vidu usmenog saopštenja izlagan 14.5.2021. godine na Četvrtoj međunarodnoj naučnoj konferenciji „Zdravlje, sport, rekreacija“, održanoj u Beogradu, u organizaciji Visoke sportske i zdravstvene škole.

³ ✉ vladimirpavlinovic@gmail.com

pokret „bacanja“ u rukometu popraćen tehničko-taktičkim zahtjevima, preciznije ga je zvati „šutiranjem“. Šutiranje se odnosi na kompleksnu kognitivno-motoričku aktivnost te mora uvijek biti promatrano u kontekstu specifičnih situacija igre.

Bez obzira na spomenuto, većina istraživanja bacanja/šutiranja u rukometu, sagledana je iz biomehaničke perspektive (Serrien et al., 2015; Van Den Tillaar & Cabri, 2012; Wagner et al., 2011). Serrien i sur. (2015) je istraživao brzinu leta lopte i kinematičke karakteristike kod rukometašica i rukometaša. Utvrdili su brži let lopte kod rukometaša, ali i različite obrasce izvođenja samog pokreta tijekom proizvodnje sile i prenošenja iste kroz kinematičke lance. Rukometaši su pokret više izvodili iz transverzalne, a rukometašice iz sagitalne ravnine (Serrien et al., 2015). Granados i sur. (2008) su istraživali izbačajnu eksplozivnost kod rukometašica tijekom jedne natjecateljske sezone te utvrdili su kako je ona značajno porasla (Granados et al., 2008). Nadalje, u studiji Fieselera i sur. (2017), provedenoj na igračima 3. lige u Njemačkoj, autori su utvrdili pozitivne korelacije brzine izbačaja sa indeksom tjelesne mase ($r=-0.50$) (Fieseler et al., 2017).

Ipak, u nijednoj autorima poznatoj studiji nije istražena brzina šuta u odnosu na poziciju iz koje se šut izvodi. Tijekom utakmice, svi igrači mogu doći u poziciju šutiranja koja geometrijski ne pripada njegovoj igračkoj poziciji (npr. krilo šutira sa vanjske pozicije). Dinamika modernog rukometa često od igrača iziskuje učinkovitost šuta u različitim situacijama igre. Univerzalnost šutiranja postaje sve važnija igračka kvaliteta u vrhunskom rukometu. Svaki igrač može doći u poziciju završnice napada izvan linije devet metara, u kontra napadu ili sa linije sedam metara. S obzirom na to da brzina šutiranja značajno utječe na uspješnost izvedbe u rukometu, razumijevanje njenih karakteristika tijekom različitih pozicija iz kojih se udarac na gol izvodi može pomoći trenerima u planiranju i izvedbi šuterskog treninga. Iz tog razloga, glavni je cilj istraživanja utvrditi razlike između različitih pozicija šuta u vrhunskom rukometu.

METODE RADA

Uzorak

Uzorak ispitanika je predstavljalo 118 igrača koji su sudjelovali na Europskom rukometnom prvenstvu koje se održalo 2020. godine u Austriji, Norveškoj i Švedskoj.

Varijable

Analizirani su samo šutovi koji su završili pogotkom, njih ukupno 784 tijekom 15 utakmica. Osim brzine šuta, ostale varijable su predstavljale sedam tipičnih pozicija šutiranja koje su ujedno i standardni parametri situacijske učinkovitosti u rukometu: šutovi izvedeni izvan devet metara (9 m), šutovi izvedeni između šest i devet metara (6 m), šutovi izvedeni sa krilnih pozicija (W), šutovi iz prolaza (BT), šutovi izvedeni iz sedmerca (7 m), šutovi izvedeni iz kontranapada (FB), i šutovi izvedeni nakon hvatanja lopte u zraku (FT).

Prikupljanje podataka

Podaci o brzini šuta (SS) prikupljeni su specijalnom rukometnom loptom iBall (SELECT, Danska) koja u sebi ima ugrađen čip (Kinexon, Njemačka). Spomenuti čip prati poziciju i brzinu lopte u realnom vremenu te prikupljene podatke šalje na server. Vrijednosti brzine leta lopte su izražene u kilometrima na sat (km/h).

Statistička obrada

Statističke analize koje su korištene u ovom istraživanju uključivale su izračunavanje osnovnih deskriptivnih statističkih parametara (aritmetička sredina, standardna devijacija, minimalni i maksimalni rezultat, rezultati Kolmogorov-Smirnovljevog testa za normalitet distribucije) i korelacijske analize za utvrđivanje odnosa između povezanih varijabli. Za sve analize korišten je softverski paket Statistica 13.0 (TIBCO Software Inc, USA).

REZULTATI

U Tabeli 1 prikazani su rezultati deskriptivne statistike udaraca na gol sa sedam različitih pozicija. Primjetna je nepravilna distribucija u varijabli brzina šuta u svim pozicijama. Slijedom toga, primijenjen je neparametrijski Kruskal-Wallis test za određivanje razlika u brzini gađanja između pozicija šuta.

Tabela 1. Deskriptivna statistika

Pozicije šuta	N	AS	SD	MIN	MAX	KS	p
9 m	212	108.80	16.90	61.00	137.00	0,08	p< .10
6 m	134	90.74	20.37	25.00	133.00	0,05	p> .20
W	151	89.11	20.12	28.00	127.00	0.08	p> .20
7 m	16	81.31	27.70	37.00	130.00	0.06	p> .20
BT	111	94.95	19.65	26.00	136.00	0.11	p< .10
FB	91	88.37	21.20	36.00	123.00	0.08	p> .20
FT	16	81.31	27.70	37.00	130.00	0.14	p> .20
ALL	787	95.41	21.23	25.00	137.00	0.05	p< .05*

Legenda: N – broj ispitanika, AS – aritmetička sredina, SD – standardna devijacija, MIN – minimum, MAX – maksimum, KS – Kolmogorov-Smirnovljevi test, **9 m** – šutovi izvedeni izvan linije devet metara izraženi u km/h, **6 m** – šutovi izvedeni izvan linije vratareva prostora izraženi u km/h, **W** – šutovi izvedeni sa krilnih pozicija izraženi u km/h, **BT** – šutovi izvedeni nakon prolaza i uskoka u vratarov prostor izraženi u km/h, **7 m** – šutovi izvedeni iz sedmerca izraženi u km/h, **FB** – šutovi izvedeni iz kontranapada izraženi u km/h, **FT** – šutovi izvedeni nakon hvatanja lopte u zraku izraženi u km/h

Prosječna brzina šuta iz različitih pozicija prikazana je na Histogramu 1. Očigledno, šutovi izvedeni sa devet metara su najbrži (108.80 km/h) dok su najsporiji šutovi izvedeni nakon hvatanja lopte u zraku i kaznenih udaraca (81.31 km/h).

U Tabeli 2 prikazane su razlike između pozicija šuta izračunate Kruskal-Wallis testom. Višestruke usporedbe Z vrijednosti u Kruskal-Wallis testu pokazale su značajne razlike između analiziranih varijabli ($H=132,1004$ p = 0.000). Post-hoc analiza otkrila je značajne razlike između šutova sa 9 m i svih drugih pozicija šutiranja. Razlike između ostalih pozicija šutiranja, osim 9 m, nisu utvrđene.

DISKUSIJA

Nepravilna raspodjela može biti razlog velikog raspona vrijednosti. Naime, kada se analiziraju različite vrste šuta u rukometnoj igri, dobro je poznato da neki od njih se nisu mogli izvesti velikom brzinom. Suprotno tome, za njihovo pravilno i učinkovito izvođenje potrebno je značajno smanjenje brzine. To znači da u ukupnoj količini analiziranih šutova postoji velik udio “sporih” šutova koji narušavaju normalitet distribucije.

Tabela 2. Razlike između pozicija šuta (Kruskal-Wallis test)

Pozicije šuta	9M R:542,17	6M R:339,50	BT R:391,73	W R:322,84	FB R:318,06	FT R:275,16	7M R:334,29
9 m							
6 m	8.08*						
BT	5.65*	1.79					
W	9.06*	0.62	2.42				
FB	7.87*	0.69	2.29	0.16			
FT	4.53*	1.07	1.92	0.80	0.70		
7 m	6.70*	0.16	1.67	0.35	0.45	0.94	

Legenda: **9 m** – šutovi izvedeni izvan linije devet metara izraženi u km/h, **6 m** – šutovi izvedeni izvan linije vratareva prostora izraženi u km/h, **W** – šutovi izvedeni sa krilnih pozicija izraženi u km/h, **BT** – šutovi izvedeni nakon prolaza i uskoka u vratarov prostor izraženi u km/h, **7 m** – šutovi izvedeni iz sedmerca izraženi u km/h, **FB** – šutovi izvedeni iz kontranapada izraženi u km/h, **FT** – šutovi izvedeni nakon hvatanja lopte u zraku izraženi u km/h

Najvažniji zaključak ove studije su značajne razlike u brzini šuta između šutova izvedenih sa 9 m i šutova sa drugih pozicija. Objašnjenje treba tražiti unutar dva čimbenika: (I) karakteristike igrača koji izvode šutove sa zadanih šuterskih pozicija, (II) karakteristike šutova koji se koriste na danim šuterskim pozicijama.

Pregled literature sugerira da se 59,15% šutova sa 9 m izvodi tehnikom šutiranja preko bloka. To je učestalija vrsta šutiranja za vanjske igrače, nego za ostale igračke pozicije. Više od 95% svih šutova s 9 m izvode igrači LB, RB, ili CB. U nekim rijetkim situacijama izvode ih i krilni igrači također (Foretic et al., 2013; Foretić et al., 2010). Tipični somatotip i kondicijski profil vanjskih igrača u rukometu je dobro dokumentiran. To su visoki, vitki i snažni sportaši, uglavnom osjetno viši od igrača na drugim pozicijama (Massuça & Fragoso, 2011; Srhoj et al., 2002; Šibila & Pori, 2009). Njihove longitudinalne dimenzije, kao što je visina, raspon ruku i/ili dužina ruku omogućuje im učinkovitije izvođenje šutova sa veće udaljenosti od drugih igrača (Sporiš et al., 2010). Za većinu ekspertnih trenera longitudinalne dimenzije najvažniji su kriteriji za izbor igrača na vanjskim pozicijama. Promatrajući zahtjeve igre opravdano je reći da će visoki igrači imati veću prednost kod šutova iz veće udaljenosti od nižih igrača. Uz eksplozivnu snagu, duže ruke, šake i visinu proizvesti će veću brzinu tijekom šutiranja (Van den Tillaar & Ettema, 2004). Najvjerojatnije u našoj studiji, većina igrača koji su izvodili šutove sa devet metara bili su vanjski igrači, te su njihov somatotip i eksplozivnost doprinijeli razlici u brzini između šuterskih pozicija.

Histogram 1. *Raspodjela prosječne brzine šutiranja sa različitih šuterskih pozicija*

Legenda: **9 m** – šutovi izvedeni izvan linije devet metara izraženi u km/h, **6 m** – šutovi izvedeni izvan linije vratareva prostora izraženi u km/h, **W** – šutovi izvedeni sa krilnih pozicija izraženi u km/h, **BT** – šutovi izvedeni nakon prolaza i uskoka u vratarov prostor izraženi u km/h, **7 m** – šutovi izvedeni iz sedmerca izraženi u km/h, **FB** – šutovi izvedeni iz kontranapada izraženi u km/h, **FT** – šutovi izvedeni nakon hvatanja lopte u zraku izraženi u km/h

Još jedan čimbenik je vrsta šuta kojeg će igrači koristiti tijekom različitih tehničko-taktičkih situacija. Promatrajući šutove koji se izvode bliže голу ukazuje na to da igrači u tim situacijama koriste raznovrsne šutove. Značajna količina tih šutova ne treba se izvoditi velikom brzinom, već velikom vještinom. Primjer su šutovi sa krilnih pozicija kada igrači imaju vrlo malo prostora, šutovi iz kontranapada kad igrači skaču “na golmana” ili kazneni udarci u kojima igrači pokušavaju nadmudriti vratara fintom ili nekakvim “lukavim šutom”. Suprotno tome, kada igrač koji šutira sa veće udaljenosti ne može nadmudriti vratara, mora “ići kroz vratara” sa najbržim mogućim šutom.

ZAKLJUČAK

Ova studija je dala zanimljiv uvid u karakteristike brzine šuta za vrijeme uobičajenih situacija šutiranja u vrhunskom rukometu za muškarce. Značajno najbrži šutovi izvođeni su sa devet metara. Razlike između šuterskih pozicija su nevažne. Sve skupa, iako nije zabilježeno, očito je da vrste i tehnike šutiranja koje se koriste na

određenim pozicijama, zajedno sa morfologijom i kondicijom igrača, utječu na brzinu šutiranja na pojedinoj poziciji šuta. Ovo je logika rukometne prakse, ali je također treba pratiti i statistički izračunavati. Budući da to nije bilo u našoj studiji, ograničenje je, ali isto tako i smjer za buduća istraživanja u području brzine šuta u rukometu. Rezultati ovog istraživanja mogu pomoći rukometnim trenerima u izboru igrača za određene pozicije i u razvoju efikasnog kondicijskog programa za specifični trening brzine i eksplozivnosti.

LITERATURA

1. Bompá, T. O. (1996). Variations of periodization of strength. *Strength and Conditioning*, 18, 58-61.
2. Fieseler, G., Hermassi, S., Hoffmeyer, B., Schultze, S., Irlenbucsh, L., Bartels, T., Delank, K. S., Laudner, K. G., & Schwesig, R. (2017). Differences in anthropometric characteristics in relation to throwing velocity and competitive level in professional male team handball: a tool for talent profiling. *The Journal of sports medicine and physical fitness*, 57(7-8), 985-992.
3. Foretic, N., Rogulj, N., & Papic, V. (2013). Empirical model for evaluating situational efficiency in top level handball. *International Journal of Performance Analysis in Sport*, 13(2), 275-293.
4. Foretić, N., Rogulj, N., & Trninić, M. (2010). The influence of situation efficiency on the result of a handball match. *Sport Science*, 3(2), 45-51.
5. Granados, C., Izquierdo, M., Ibanez, J., Ruesta, M., & Gorostiaga, E. M. (2008). Effects of an entire season on physical fitness in elite female handball players. *Medicine & Science in Sports & Exercise*, 40(2), 351-361.
6. Massuça, L., & Fragoso, I. (2011). Study of Portuguese handball players of different playing status. A morphological and biosocial perspective. *Biology of Sport*, 28(1).
7. Raudsepp, L., & Päll, P. (2006). The relationship between fundamental motor skills and outside-school physical activity of elementary school children. *Pediatric exercise science*, 18(4), 426-435.
8. Serrien, B., Clijsen, R., Blondeel, J., Goossens, M., & Baeyens, J. P. (2015). Differences in ball speed and three-dimensional kinematics between male and female handball players during a standing throw with run-up. *BMC sports science, medicine and rehabilitation*, 7(1), 1-12.
9. Sporiš, G., Vuleta, D., Vuleta Jr, D., & Milanović, D. (2010). Fitness profiling in handball: physical and physiological characteristics of elite players. *Collegium antropologicum*, 34(3), 1009-1014.
10. Srhoj, V., Marinović, M., & Rogulj, N. (2002). Position specific morphological characteristics of top-level male handball players. *Collegium antropologicum*, 26(1), 219-227.
11. Šibila, M., & Pori, P. (2009). Position-related differences in selected morphological body characteristics of top-level handball players. *Collegium antropologicum*, 33(4), 1079-1086.
12. Van Den Tillaar, R., & Cabri, J. M. (2012). Gender differences in the kinematics and ball velocity of overarm throwing in elite team handball players. *Journal of Sports Sciences*, 30(8), 807-813.
13. Van den Tillaar, R., & Ettema, G. (2004). Effect of body size and gender in overarm throwing performance. *European journal of applied physiology*, 91(4), 413-418.
14. Wagner, H., Pfusterschmied, J., Von Duvillard, S. P., & Müller, E. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of sports science & medicine*, 10(1), 73.

Original scientific paper

SHOOTING VELOCITY DIFFERENCES BETWEEN SHOOTING POSITIONS IN TOP LEVEL HANDBALL^{1 2}

UDC: 796.322.012.574

DOI: 10.5937/snp2102077F

Nikola Foretić

Faculty of Kinesiology, University of Split, Croatia

Vladimir Pavlinović³

Faculty of Kinesiology, University of Split, Croatia

Šime Veršić

Faculty of Kinesiology, University of Split, Croatia

Abstract: Shooting velocity is one of the most important features that influence successful shooting performance in handball. Therefore, the aim of this study was to determine differences in shooting velocity between shooting positions in top level handball. A total of 784 shots were analyzed. Shooting velocity was measured with iBall (SELECT, Denmark), that has a built-in chip for tracking and distributing data in real time regarding ball velocity, shot detection, shot position and the position of the ball in the goal (Kinexon, Germany). Shooting position (SP) is defined as a geometrical point and a tactical situation from which a shot was taken. Differences between shooting positions were calculated using the Kruskal-Wallis test. Significant difference in shooting velocity was noticed between shooting positions (Chi-Square=95.83). Post-hoc analysis revealed that shots executed outside the nine meter perimeter are significantly faster than from other shooting positions. Shots taken outside the 9-meter perimeter require the fastest shots since players cannot outsmart goalkeepers with modified slow shots (e.g. lob shot, shot with rotation or “dry leaf” shot). Modified slow shots are commonly used in closer distance shots like wing shot, fast break shot, break-through shot or penalty shot. In these situations, players have more demanding angle in which shooting velocity is not always an advantage.

Keywords: *shot velocity, ball velocity, professional handball, throwing, team sport*

INTRODUCTION

Throwing is considered to be a fundamental motor skill. Its execution is very natural and athletes learn it at early stages of sports development (Bompa, 1996; Raudsepp & Päll, 2006). As such, throwing motion is very common in a majority of team ball games. It can be found in a variety of sports' techniques in which athletes are required to score using their hand. In some sports scoring is more oriented on aiming and precision (e.g. basketball, rugby) while in others throwing action is more affected by explosive power (e.g. water polo, American football).

Handball belongs to the category of sports in which throwing should be executed as explosively as possible without losing precision. Control on the ball is maintained by the ball size (its volume and weight) and special glue

¹ Paper received: 28 April 2021, accepted for publication: 10 June 2021.

² This paper was presented orally on 14 May 2021 at the 4th International Scientific Conference “Health, Sport, Recreation” held in Belgrade and organized by the College of Sports and Health.

³ ✉ vladimirpavlinovic@gmail.com

that helps players manipulate the ball and perform specific shots (e.g. rotational shot). As handball throwing on goal is always accompanied by technical-tactical requirements, it is more precise to call it “shooting”. Shooting though implies a more complex cognitive and motor action and should be put in the context of specific game situations.

Nevertheless, a majority of studies dealing with throwing/shooting in handball have been conducted from the biomechanical perspective (Serrien et al., 2015; Van Den Tillaar & Cabri, 2012; Wagner et al., 2011). Serrien et al. (2015) researched ball velocity and three-dimensional kinematics between male and female handball players. They found faster shooting in male players and distinct strategies in generating and transferring momentum through the kinematic chain. Male players showed more activity in the transverse plane whereas female players showed more activity in the sagittal plane (Serrien et al., 2015). Granados et al. (2008) studied one handball season which they noticed resulted in significant increases in throwing velocity of elite female handball players. In their study, Fieseler et al. (2017) reported that throwing velocity was in correlation with BMI ($r=-0.50$) among the third German handball league players.

However, no study explored shooting velocity in different shooting positions. During play, different players can find themselves in a shooting position that is not typical for the geometry of their own playing position. The dynamics of modern handball force players to be efficient in a variety of situations. Universality is becoming a more and more important quality for every player regardless of their “typical position”. For any player, a shooting action can occur outside the 9-meter perimeter, in fast break, penalty shot, in breakthrough or from the 6-meter line. Knowing that shooting velocity is one of the factors that significantly influence performance in handball, understanding the nature of this feature in different shooting positions could help a lot to coaches in terms of selection and composition of a training program. Hence, the aim of this study was to conduct a research of shooting velocity differences among different shooting positions in top level handball.

METHOD

Samples

Participants in this study involved 118 handball players who took part in the 2020 European Handball Championship held in Austria, Norway and Sweden.

Variables

Shooting velocity was reported only for scored goals. A total of 784 shots/goals scored in 15 games were analysed. Apart from shooting velocity, other variables included 7 typical shooting positions that are part of standard parameters of situational efficiency in handball: shots taken outside the nine-meter perimeter (9m), shots taken between 9m and the goalkeeper area (6m), shots taken from right- and left-wing positions (W), breakthrough shots (BT), penalty shots (7m), fast break shots (FB), and flying throw shots (FT).

Data collection techniques

Shooting velocity (SV) was collected using iBall (SELECT, Denmark), with a built-in chip that tracks and distributes data in real time (Kinexon, Germany). The values of shooting velocity are presented in kilometres per hour (km/h).

Statistical analysis

Statistical analysis involved the calculation of descriptive statistical parameters (arithmetic means and standard deviations, minimum and maximum measurement values and the Kolmogorov-Smirnov test for testing normality of distribution) and correlation analysis (Pearson's product-moment) to determine the relationship between the observed variables. For all analyses, Statistica 13.0 (TIBCO Software Inc, USA) was used, and a p-level of 95% was applied.

RESULTS

Table 1 shows the results of descriptive statistics calculated for shots taken from 7 different shooting positions. Uneven distribution is noticed in shooting velocity for all positions (ALL). Consequently, the nonparametric Kruskal-Wallis test was applied to determine the differences in shooting velocity between shooting positions.

Table 1. *Descriptive statistics*

Shooting positions	N	MEAN	SD	MIN	MAX	KS	P
9 m	212	108.80	16.90	61.00	137.00	0.08	p< .10
6 m	134	90.74	20.37	25.00	133.00	0.05	p> .20
W	151	89.11	20.12	28.00	127.00	0.08	p> .20
7 m	16	81.31	27.70	37.00	130.00	0.06	p> .20
BT	111	94.95	19.65	26.00	136.00	0.11	p< .10
FB	91	88.37	21.20	36.00	123.00	0.08	p> .20
FT	16	81.31	27.70	37.00	130.00	0.14	p> .20
ALL	787	95.41	21.23	25.00	137.00	0.05	p< .05*

Legend: **N** – number of subjects, **MEAN** – arithmetic mean, **SD** – standard deviation, **MIN** – minimum, **MAX** - maximum, **KS** – Kolmogorov-Smirnov test, **9m** – shots taken outside the nine meter perimeter presented in km/h, **6m** – shots taken between nine meters and the goalkeeper area presented in km/h, **W** – shots taken from right- and left-wing positions presented in km/h, **BT** – breakthrough shots presented in km/h, **7m** – penalty shots presented in km/h, **FB** – fast break shots presented in km/h, **FT** – flying throw shots presented in km/h

The average shooting velocity from different shooting position is presented in Figure 1. Evidently, shots taken outside the 9 meter perimeter are the fastest (108.80 km/h) while the slowest shots were executed from flying throw and penalty shots (81.31 km/h, respectively).

Table 2 shows the results of the Kruskal-Wallis test that calculated the differences between shooting positions. Multiple comparisons of z' values in the Kruskal-Wallis test showed significant differences between the analysed variables (H=132,1004 p=0.000). Post-hoc analysis revealed significant differences between 9m shots and shots from all other shooting positions. Differences between shooting positions other than 9m were not established.

DISCUSSION

Irregular distribution could be the cause of a vast value span. Namely, when analysing different shot types in handball it is well known that some of them could not be performed at high velocity. On the contrary, to execute them correctly and efficiently, a significant reduction in velocity is required. This means that in the total amount of analysed shots there is big share of “slow” shots that disturb the normality of distribution.

Table 2. *Differences between shooting positions (Kruskal-Wallis test)*

Shooting positions	9M	6M	BT	W	FB	FT	7M
	R:542,17	R:339,50	R:391,73	R:322,84	R:318,06	R:275,16	R:334,29
9M							
6M	8.08*						
BT	5.65*	1.79					
W	9.06*	0.62	2.42				
FB	7.87*	0.69	2.29	0.16			
FT	4.53*	1.07	1.92	0.80	0.70		
7M	6.70*	0.16	1.67	0.35	0.45	0.94	

Legend: **9m** – shots taken outside the nine-meter perimeter presented in km/h, **6m** – shots taken between nine meters and the goalkeeper area presented in km/h, **W** – shots taken from right- and left-wing positions presented in km/h, **BT** – breakthrough shots presented in km/h, **7m** – penalty shots presented in km/h, **FB** – fast break shots presented in km/h, **FT** – flying throw shots presented in km/h

The most important finding of this study are the significant differences in shooting velocity between shots taken outside the 9-meter perimeter and shots from other shooting positions. Explanations should be sought in 2 factors: (I) the characteristics of players who perform shots from the given shooting positions, (II) the characteristics of the shots used in the given shooting positions.

Literature review suggests that 59.15% of the shots from 9 meters are performed by shooting over the block technique. This type of shooting is much more frequently found among back players than in other playing positions. Over 95% of all 9-meter shots are performed by LB, RB or CB players. In some rare situations wing players perform them as well (Foretic et al., 2013; Foretić et al., 2010). The typical somatotype and fitness profile of back players in handball is well documented. They are tall, lean and powerful athletes, mostly significantly taller than players in other positions (Massuça & Fragoso, 2011; Srhoj et al., 2002; Šibila & Pori, 2009). Their longitudinal dimensions, such as height, arm span and/or arm length allow them to execute distance shots more efficiently than other players (Sporiš et al., 2010). For a majority of expert coaches, longitudinal dimensions are the most important criteria in the selection of back players. After observing game situations and position demands it is logical to say that tall player will have more advantage in shooting actions from distance than shorter ones. Along with explosive power, longer arms, hands and height will produce more velocity during shooting actions (Van den Tillaar & Ettema, 2004). Most probably in our study, a majority of players that performed shots from 9 meters were back players and their somatotype and explosiveness contributed to the velocity differences between shooting positions.

Figure 1. Average shooting velocity distribution from different shooting positions

Legend: **9m** – shots taken outside the nine-meter perimeter presented in km/h, **6m** – shots taken between nine meters and the goalkeeper area presented in km/h, **W** – shots taken from right- and left-wing positions presented in km/h, **BT** – breakthrough shots presented in km/h, **7m** – penalty shots presented in km/h, **FB** – fast break shots presented in km/h, **FT** – flying throw shots presented in km/h

Another factor is characteristic of shots that players use during different technical-tactical situations. Observations of shots that are executed closer to the goal indicate that in those situations' players use a variety of shots. A significant amount of those shots does not have to be performed with high ball velocity but using a high level of skill. Good examples are shots from wing position when players have very small shooting area, breakthrough shots when player jumps directly "at the goalkeeper" or penalty shots in which player tries to outsmart the goalkeeper with a feint or a "cunning shot". On the contrary, when shooting from a long distance, a player cannot outsmart the goalkeeper, but rather "pass the goalkeeper" with the fastest shot possible.

CONCLUSION

This study provides an interesting insight in the characteristics of shooting velocity in standard shooting situations in top level male handball. Significantly, the fastest shots are those performed from 9 meters. The differ-

ences between other shooting positions are irrelevant. All in all, although not recorded, it is obvious that the types of shots and shooting technique used in a particular position, along with players' morphology and fitness, influence shooting velocity in shooting positions. This is the logic in handball but it should also be monitored and statistically calculated. Since this was not encompassed in our study, it represents a limitation but also a direction for future research in the area of shooting velocity in handball. The results of this research can help handball coaches in the selection of players for particular positions and in developing an efficient conditioning program for specific power and velocity training.

REFERENCES

1. Bompa, T. O. (1996). Variations of periodization of strength. *Strength and Conditioning*, 18, 58-61.
2. Fieseler, G., Hermassi, S., Hoffmeyer, B., Schultze, S., Irlenbucsh, L., Bartels, T., Delank, K. S., Laudner, K. G., & Schwesig, R. (2017). Differences in anthropometric characteristics in relation to throwing velocity and competitive level in professional male team handball: a tool for talent profiling. *The Journal of sports medicine and physical fitness*, 57(7-8), 985-992.
3. Foretic, N., Rogulj, N., & Papic, V. (2013). Empirical model for evaluating situational efficiency in top level handball. *International Journal of Performance Analysis in Sport*, 13(2), 275-293.
4. Foretić, N., Rogulj, N., & Trninić, M. (2010). The influence of situation efficiency on the result of a handball match. *Sport Science*, 3(2), 45-51.
5. Granados, C., Izquierdo, M., Ibanez, J., Ruesta, M., & Gorostiaga, E. M. (2008). Effects of an entire season on physical fitness in elite female handball players. *Medicine & Science in Sports & Exercise*, 40(2), 351-361.
6. Massuça, L., & Fragoso, I. (2011). Study of Portuguese handball players of different playing status. A morphological and biosocial perspective. *Biology of Sport*, 28(1).
7. Raudsepp, L., & Päll, P. (2006). The relationship between fundamental motor skills and outside-school physical activity of elementary school children. *Pediatric exercise science*, 18(4), 426-435.
8. Serrien, B., Clijsen, R., Blondeel, J., Goossens, M., & Baeyens, J. P. (2015). Differences in ball speed and three-dimensional kinematics between male and female handball players during a standing throw with run-up. *BMC sports science, medicine and rehabilitation*, 7(1), 1-12.
9. Sporiš, G., Vuleta, D., Vuleta Jr, D., & Milanović, D. (2010). Fitness profiling in handball: physical and physiological characteristics of elite players. *Collegium antropologicum*, 34(3), 1009-1014.
10. Srhoj, V., Marinović, M., & Rogulj, N. (2002). Position specific morphological characteristics of top-level male handball players. *Collegium antropologicum*, 26(1), 219-227.
11. Šibila, M., & Pori, P. (2009). Position-related differences in selected morphological body characteristics of top-level handball players. *Collegium antropologicum*, 33(4), 1079-1086.
12. Van Den Tillaar, R., & Cabri, J. M. (2012). Gender differences in the kinematics and ball velocity of overarm throwing in elite team handball players. *Journal of Sports Sciences*, 30(8), 807-813.
13. Van den Tillaar, R., & Ettema, G. (2004). Effect of body size and gender in overarm throwing performance. *European journal of applied physiology*, 91(4), 413-418.
14. Wagner, H., Pfusterschmied, J., Von Duvillard, S. P., & Müller, E. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of sports science & medicine*, 10(1), 73.