COMPARISON OF KINEMATIC PARAMETERS OF JUMP SHOT PERFORMANCE BY FEMALE HANDBALL PLAYERS OF DIFFERENT AGES

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Abstract

The basic aim of this research was to analyze kinematic parameters when performing a jump shot. The sample of entities consisted of four female handball players, potential candidates for the Croatian national teams in their age categories (a junior, an under eighteen, an under-fifteen and a girl). The kinematic variables sample set was made up from the parameters related to the specific phases of a jump shot and they referred to: move of the body's centre of gravity (CG) by horizontal and vertical plane, the velocity of the body's centre of gravity in a horizontal and vertical plane, maximum linear velocity of some body segments and their activation in time. From the series of seven attempts, the throws with the highest ball flight velocities were chosen for each of the subjects and they were explained in detail by kinematic variables observed. It is possible to use registered kinematic parameters to explore the execution of the jump shot by the sample subjects, with the purpose to detect the characteristics of the jump shot. These features, then, might be used to improve and correct the performances of the players within the process of their technical development (correcting mistakes), i.e. they might be considered as indicators relevant for directing the future training process in general.

Key words: *kinematic analysis, female handball players, jump shot*

Introduction

Shooting at a goal in an attempt to score and thus securing the advantage over the opponent is the final aim of every handball match. The efficiency in the performance of a jump shot is defined by a number of factors, whereas the technical correctness of the performance is one of the most important. "Biomechanics measuring enables exact, quantified analysis of the technique elements, that subsequently becomes a standard of a training process, being the factor of a successful training programming, especially when it comes to diagnosing the level of the performance technique and its monitoring within the process of personal improvement of an athlete and furthermore, in selection of the kinesiological operators and modelling methodical procedures" (Mejovšek, et al., 1997). Throwing and aiming at a goal, i.e. the phase of releasing the ball or some other objects, in different sports, was interesting to numerous experts from the aspect of the analysis of kinematic parameters. Individual analysis of throws in different disciplines: baseball (Escamilla, 1998), water-polo (Feltner, & Taylor, 1997), handball (Coleman, Benham, & Northcott, 1993), javelin throw (Best, Bartlett, & Morriss, 1993) pointed at the similar principles of performing a throw (proximal-to-distal segmental sequence). The subsequent, related research included the comparative analysis of the registered kinematic parameters in those disciplines (Bergün, 2008; Van den Tillar, 2005). Research of kinematic parameters in handball were predominantly directed to analysis of the performance of non-jumping throws and they showed linear velocities of different body segments (Tuma & Zahalka, 1997; Jöris et al., 1985; Van den Tillar & Ettema, 2003; Fradet at al., 2004) and angular velocities of certain body joints at the time of throw (Van den Tillar & Ettema, 2004; Fradet et al. 2004). The analysis of jump shots, which are the most frequent handball elements directed towards realization, covered mostly individual analyses of the elite handball players (Hraski & Zvonarek, 1996; Zvonarek, Hraski & Vuleta 1997; Pori et al., 2005; Wagner, Klos & Müller, 2006). The papers mentioned described the parameters gained at specific phases of a jump shot. The basic aim of this case study is, however, to analyse kinematic parameters at the time a jump shot is being performed by the female handball players of different ages. Since performing a jump shot consists of 5 phases: approach, take-off, flight, throw and landing (Zvonarek & Hraski, 1996; Zvonarek, Hraski & Vuleta, 1997), the attention of this paper is given to the analysis of kinematic parameters at the separate phases of the jump shot.

Methods

Sample of entities

The sample of entities consisted of 4 female handball players who are potential candidates for Croatian national teams at their age (Table 1). All subjects are right-handed left-wing players.

Table 1. The sample of entities

Subjects	Year of birth	Body height (cm)	Body mass (kg)	Category
Je. Vi.	1990	182.0	63.0	Junior
Am. Ka.	1993	174.0	61.0	Under-eighteen
Te. Kr.	1995	171.0	55.0.	Under-fifteen
Do. Pr.	1996	178.0	55.0	Girls

Kinematic sample variables
A set of variables analysed in the earlier research of jump shot (Zvonarek & Hraski, 1996; Pori, Bon & Šibila, 2005) represented the basis for the choice of kinematic variables. It included specific phases of the jump shot referring to: shift of the body's centre of gravity by horizontal and vertical plane, CG velocity in horizontal and vertical plane, maximum linear velocity of some body segments and their activation in time. In order to describe the specific phases of a jump shot in more detail, the applied (common) variable set was supplemented with variables specially marked with * (Table 2). Namely, the biomechanic (kinematic) research of the basic jumping athletic disciplines (long and high jump) showed that the optimal relation of certain kinematic parameters determines the efficiency of the performance (Antekolović, 2002; Blažević, 2006). In this case study, the conclusions reached by the research mentioned above, established the basic criterion for complementation of the kinematic variables set when investigating the approach and the take-off phase by a handball jump shot performance: lowering of the body's centre of gravity (2 approach), the length of the last stride (3 flight), the angle of the knee joint (11 take-off), the angle of the take–off (12 take-off). The time variable that measures a period when player holds a ball with one hand till the time of its throw (5), aims at broadening the interpretation of the efficiency in executing a jump shot.

Acquisition of the video data for kinematic analysis
Acquisition of the video recordings for kinematic analysis was completed on October 30th, 2009 in the gym of Faculty of Kinesiology University of Zagreb. Video recording was made by two camcorders (Handycam SonyHDR-HC9 MiniDV Camcorder, with the frequency of 50 pictures per second and shutter speed 1/600). Camcorders were positioned in such a way that, after registration of 18 referential points + ball and calibration frame, they provided the possibility for a 3D space analysis (Figure 1) For the purpose of the research, a calibration frame (180x180x180) was set at the free-throw line (9m – x axis), running vertically to the crossbar at the six-meter zone line (6m – z axis).

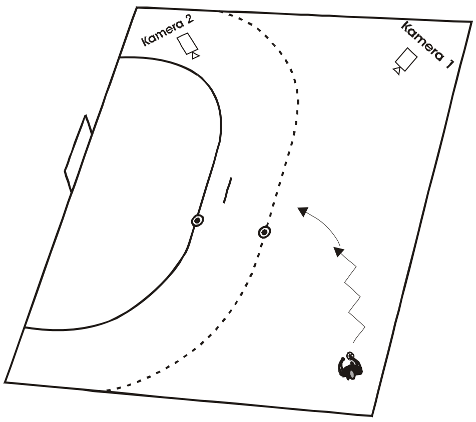

Figure1. Outline of the video recording

Before making the recording, a calibration frame, as well as a fixed, i.e. still point, visible throughout the complete process of recording, were recorded, by using both camcorders. The subjects got warmed up, according to the standard training and competition 20-minute warm-up procedure and then they performed several test jump shots in order to check the position of the calibration frame. The subjects had to execute the jump shot in the following manner: they started from the vertical line on the left side of the playing court at a 15m distance from the goal. First they made several introducing steps and then they performed a half-circular three-step approach to the middle of the court. After that, they performed a jump shot from a previously marked area, 8,5-9m away from the goal line. They were asked to perform the shots in the way identical to the one they would present in an actual playing situation. Each subject executed 7 shots at a goal and by each attempt the ball velocity was measured by radar (Stalker PRO) and the segment of the goal hit by the ball (Table 3, Figure 2) was registered. We presumed that, when measuring the reached throw velocities, the higher velocities would be performed by senior handball players, taking into consideration the longer continuous time they had spent in training and playing matches, which resulted in a higher number of iterations and probably in an automation of the movement. When considering the developmental phases in the area of the basic motor abilities (explosive strength by take-off and throw of the ball, as well as the velocity of the individual movement), it could be presumed that the higher values should be also reached by the same age group.

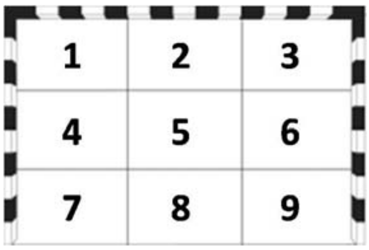

Figure 2. Goal segments

Calculation of the kinematic parameters
Video recording processing and kinematic parameters calculation was performed by Ariel Performance Analysis System (APAS, Ariel Dynamics inc., USA). Video recordings were saved in .avi format in a computer and afterwards the elements to be analysed were isolated. For each of the subjects, the fastest (according to the velocities registered by radar) and the most precise (the ball hit the space between the two goalposts) shots were prepared for the analysis. The preparation included isolation of the part of the movement (jump shot) from positioning the right foot on the ground (the last approach stride) till the moment of the first contact with the ground after performing a jump shot (the landing). The majority of the variables expected were calculated directly by APAS and partly by the appropriate trigonometric functions on the basis of the data from APAS.

Results and discussion

The results of each of the four players, for every phase of the jump shot observed, are shown in the table.

Table 2. Kinematic variables

		KINEMATIC VARIABLES	MEASURING UNIT
APPROACH	1	Horizontal velocity change by the time of the take-off - foot placement in the last stride	m/s
	2	Lowering the body's centre of gravity in the last stride*	cm
	3	Length of the last stride *	cm
	4	Duration of the last stride	s
	5	Time of holding the ball with one hand till the throw*	s
TAKE-OFF	1	Horizontal velocity CG at the beginning of the take-off (placement)	m/s
	2	Horizontal velocity CG at the end of the take-off (separating)	m/s
	3	Decrease of horizontal velocity	m/s
	4	Vertical velocity CG at the beginning of the take-off	m/s
	5	Vertical velocity at the end of the take-off	m/s
	6	Increase of vertical velocity	m/s
	7	Duration of the take-off	s
	8	Height of centre of body gravity at the moment of foot placement	cm
	9	Height of centre of body gravity at the end of the take-off	cm
	10	Change of the height of centre of body gravity	cm
	11	Angle of the knee joint (placing the take-off foot)*	º
	12	The angle of the take-off*	º
FLIGHT	1	Maximum velocity of the flight phase CG	cm
	2	Time of reaching the maximum height CG at the flight phase	s
	3	Duration of the flight	s
	4	Horizontal move CG till the moment of the throw	cm
THROW	1	Height of the body's centre of gravity at the time of throw	cm
	2	Maximum height loss CG	cm
	3	Period from the take-off till the throw of the ball	s
	4	Height of the throw	cm
	5	Velocity of the ball at the time of throw	m/s
	6	Height of the throw	cm
	7	Linear peak velocity of the hip	m/s
	8	Time of reaching the linear peak velocity of the hip	s
	9	Linear peak velocity of the shoulder	m/s
	10	Time of reaching the linear peak velocity of the shoulder	s
	11	Linear peak velocity of the elbow	m/s
	12	Time of reaching the linear peak velocity of the elbow	s
	13	Linear peak velocity of the wrist	m/s
	14	Time of reaching the linear peak velocity of the wrist	s
	15	Linear peak velocity of the hand	m/s
	16	Time of reaching the linear peak velocity of the hand	s
	1	Height of the body's centre of gravity at the time of contact with the ground	cm

*variables with the mark represent the complementation of the common variables set

Table 3. Velocity and precision of the jump shots recorded for every subject

Jumping -shot	1		2		3		4		5		6		7	
subjects	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.	Velocity (km/h) (m/s)	Goal seg.
Je. Vi.	70.2 19.5	6	72.2 20.1	3	78.2 21.7	v	78.6 21.8	0	75.8 21.0	4	81.5 22.6	3	**85.6*** **23.7**	**3***
Am. Ka.	73.0 20.3	4	75.3 20.9	6	75.3 20.9	4	73.8 20.5	3	75.3 20.9	4	**78.4*** **21.8**	**4***	71.0 19.7	0
Te. Kr.	71.5 19.9	3	75.3 20.9	9	73.7 20.4	6	74.6 20.7	4	68.5 19.0	3	**77.3*** **21.5**	**7***	71.8 19.9	3
Do. Pr.	73.8 20.5	6	70.7 19.6	3	69.6 19.3	1	74.9 20.8	3	76.5 21.3	1	71.0 19.7	3	**77.6*** **21.6**	**3***

*the shots marked specially (*) were processed by APAS (kinematic parameters)

Table 4. Approach phases

Variables	Je. Vi.	Am. Ka.	Te. Kr.	Do. Pr.
Horizontal velocity change by the time of the take-off - foot placement in the last stride	0.58	0.38	0.37	0.31
Lowering the body's centre of gravity in the last stride*	3.27	10.50	4.56	7.59
Length of the last stride *	125.62	128.71	137.61	134.75
Duration of the last stride	0.26	0.22	0.30	0.44
Time of holding the ball with one hand till the throw*	0.76	0.48	0.58	0.74

Table 5. The take-off phase

Variable	Je Vi	Am Ka	Te Kr	Do Pr
Horizontal velocity CG at the beginning of the take-off	3.43	3.25	2.96	3.63
Horizontal velocity CG at the end of the take-off (separating)	3.27	2.75	2.74	3.24
Decrease of horizontal velocity	-0.16	-0.50	-0.22	-0.39
Vertical velocity CG at the beginning of the take-off	0.48	0.44	0.16	0.85
Vertical velocity at the end of the take-off	1.75	2.28	2.31	2.14
Increase of vertical velocity	1.27	1.84	2.15	1.29
Duration of the take-off	0.22	0.18	0.24	0.18
Height of the body's centre of gravity at the moment of foot	97.33	92.29	87.53	91.18
Height of the body's centre of gravity at the end of the take-off	123.51	118.45	115.18	119.63
Change of the height of the body's centre of gravity	26.18	26.16	27.65	28.45
Angle of the knee joint (placing the take-off foot) (º)	159.09	155.46	168.26	153.54
The angle of the take-off(º)	28.15	39.66	40.13	33.44

Table 6. Flight phase

Variables	Je Vi	Am Ka	Te Kr	Do Pr
Maximum velocity of the flight phase CG	143.97	145.68	139.06	145.81
Time of reaching the maximum height CG at the flight phase	-0.08	-0.06	-0.16	-0.06
Duration of the flight	0.38	0.52	0.46	0.52
Horizontal move CG till the moment of the throw	91.06	82.95	96.87	95,32

Table 7. The throw phase

Variables	Je Vi	Am Ka	Te Kr	Do Pr
Height of the body's centre of gravity at the time of throw	140.48	142.81	127.53	143.08
Maximum height loss CG	3.49	2.87	11.53	2.73
Period from the take-off till the throw of the ball	0.28	0.30	0.36	0.30
Height of the throw	24.62	22.00	21.81	21.60
Velocity of the ball at the time of throw	243.21	244.59	213.21	243.40

Table 8. Peak velocities and the time activation

	Je Vi	Am Ka	Te Kr	Do Pr	Je Vi	Am Ka	Te Kr	Do Pr	
	peak – maximum velocities (m/s)				time activation (s)				
Hip	5.60	5.62	5.34	4.82	-0.18	-0.18	-0.16	-0.16	Hip
Shoulder	6.10	5.17	5.19	6.14	-0.08	-0.12	-0.16	-0.10	Shoulder
Elbow	10.79	10.61	10.59	9.75	-0.06	-0.08	-0.08	-0.08	Elbow
Wrist	14.04	12.48	12.37	14.91	-0.02	-0.02	-0.02	-0.02	Wrist
Palm	17.46	16.05	15.99	17.39	-0.02	-0.02	-0.02	-0.02	Palm

Table 9. Landing parameters

Variables	Je Vi	Am Ka	Te Kr	Do Pr
Height of the body's centre of gravity at the time of contact with the ground	117.10	104.94	109.96	106.05

Approach

Contemporary trends of playing handball are based on accelerating the game, which reflects on the attacks, where the players tend to adapt the performance of all of the technical elements to the new concepts, especially when it comes to shooting. The projection of such trends becomes recognizable in shortening of the approach ('shooting from the first stride') with the purpose of a timely (fast) reaction to the well positioned defending players. The purpose of approach is to gain an optimal horizontal velocity which will then be transformed into a take-off. The basic part of an approach consists of two or three strides, preceding the take-off and these should form a horizontal impulse sufficient enough for an efficient (high) jump (Zvonarek & Hraski, 1996).

According to Pori, Bon & Šibila (2005), the basic characteristics of an approach, evaluated with an excellent mark are: optimal length of the last stride and simultaneous (synchronous) lowering of the body's centre of gravity, smooth, fluid and rhythmic performance without any difficulty. When comparing the measured kinematic parameters of the approach among the subjects, we noticed the increase of the horizontal velocity of the last stride, the greatest one being the one noticed by the oldest player (Je.Vi. – 0.58 cm). Trajectory of the body's movement CG points at the general lowering, for Am.Ka., amounting the highest 10.50 cm. Te.Kr. had the longest last stride (137.61 cm) and she was followed by the youngest Do.Pr. whose stride lasted longest (0.44s).

Analysis of the data measured by the period of controlling a ball with one shooting hand variable, showed that it would be more adequate if the period of controlling the ball with both hands was shorter and if the ball was shifted to a shooting hand as soon as possible when performing the last stride (Je.Vi. t=0.78). In this way, the accumulation and generation of the maximum energy would be directed to the part of the body participating in the throw (in comparison to the rest of the examinees, Je.Vi. reached the maximal velocity of the ball throw).

Take-off

The take-off phase is a time period from the first to the last contact of the take-off foot with the ground. Successfulness in making a long jump, i.e. the length of the jump, is precisely determined by the indicators created during the approach and the take-off phase. The very parable of the flight CG is determined by: CG horizontal velocity, CG vertical velocity, angle of the take-off, the CG height at the moment of the take-off. A good relationship among the constituents determines how successful the long jump will be (according to Antekolović, 2002).

When performing a jump shot, at the time of the take-off, the release of the ball is also being prepared and this preparation includes the raising of the ball with a circular movement backwards and above the shoulder of the shooting arm. The take-off is supported by the raising of the swinging leg, which later, at the phase of the throw, takes over the role of a footing for initialising a release swing (according to Zvonarek & Hraski, 1996). Pori, Bon & Šibila (2005) consider the take-off excellent if the take-off foot is positioned precisely towards the goal and if the take-off is vertical, explosive and elastic. According to the research of some athletic disciplines (long and high jump), horizontal velocity decreases, whereas vertical velocity of the body CG increases at the take-off phase. Such regularity was also registered in our analysis of the jump shots of the observed handball players, although the accomplished values were substantially lower. The decrease of the horizontal velocity varies from 0.16 m/s to – 0.50 m/s, and the increase of the vertical from 1.75 m/s to 2.28 m/s. The change of the height of the body's gravity centre covers the range from 26.18 cm to 28.45 cm, the angle of the knee joint from 153.54° to 168.28°, and the angle of the take-off from 28.15° to 40.13°. When examining the video recordings, in the process of which we paid special attention to the beginning of the take-off phase, it was noticed, that three out of four players realise the contact with the surface by positioning the heel first, while the youngest Do.Pr. starts the take-off phase by placing the top of the foot on the ground first. The conditions for a successful transformation of a horizontal to a vertical take-off impulse are based on making the surface contact with the whole foot at the take-off phase, which indicates that there is an area where it becomes necessary to make corrections by all the tested players, with the purpose of exploiting the potentials of the basic motor functions, which, because of the incorrect technique, cannot be used to their maximum. The lowest increase of the vertical velocity was recorded by the subject Je.Vi. whose ball velocities in the flight towards a goal reached the highest values. The possible explanation for this lies in the fact that this subject, in her jump shot improving training practice, had been focused on the speed of the reaction with regard to the defending players and the goalkeeper, rather than on shooting over the block. The youngest Do.Pr performed repeatedly jump shots that showed a tendency of a high take-off, which probably represents an inertial continuation of the movement in horizontal direction after the approach, due to the insufficient confidence in the intensity with which she can throw the ball, when transforming horizontal into vertical velocity, at the time of the take-off.

The potential factors conditioning such a performance might be the consequence of the limitations typical of every experimental procedure. It is possible that the attention of the players, because of the radar measurement, was only partly on the intensity of the throw of the ball. The lack of defensive players caused decreased concentration level of the subjects on the vertical component of the take-off.

Flight

In the moment when the take-off foot becomes detached from the surface, the flight phase begins and its basic characteristics, that can be evaluated with an excellent mark, according to Pori, Bon & Šibila (2005), are defined as pertaining of the body's lateral position and activation of the swing leg at the flight phase till the throw. At this phase, the maximum body's centre of gravity height among the observed handball player's amounts from 139.06 cm till 145.84 cm moves CG in a horizontal plane amount from 82.95 to 96.87, whereas the complete duration of the flight is from 0.38 s till 0.52 s.

The throw of the ball

The throw of the ball is being performed at the flight phase. The experts (Pori, Bon & Šibila, 2005) consider the throw phase excellent if: the elbow is positioned high at the head level, the particular muscle groups in the kinetic chain of the throw performance are adequately activated and if the very performance is explosive. The calculated parameters of the maximum height loss CG reveal that none of the players performs the throw at the highest point of the flight, but later. With respect to this, Te.Kr. who performed a characteristic "delayed shot" (the greatest maximum height loss of 11.53 cm in comparison to other players), has the greatest deviation. Je. Vi. has the shortest period from the moment of the take off till the throw. (0.28 s), which factually supports the previous interpretation of her approach, as well as the complete way of shooting shown by that player. At the throw phase, the parameters referring to the functioning of the kinetic chain were specially isolated: peak (maximum) velocities of the relevant joints and the order of accomplishing peak velocity (time activation). Some research point at the questionable quality of the functioning of the successive activation, i.e. of the energy transfer existence, as well as the existence of velocities from proximal to distal parts of the body, when performing shots in handball (Fradet, 2004; Van den Tillaar, 2009). Our case study, regarding the maximum linear velocities of particular body segments, revealed that the progression of linear velocities does not exist by all the players (the values of the shoulder linear velocities of Am.Ka. and Te.Kr. are smaller in relation to the hip linear velocities).

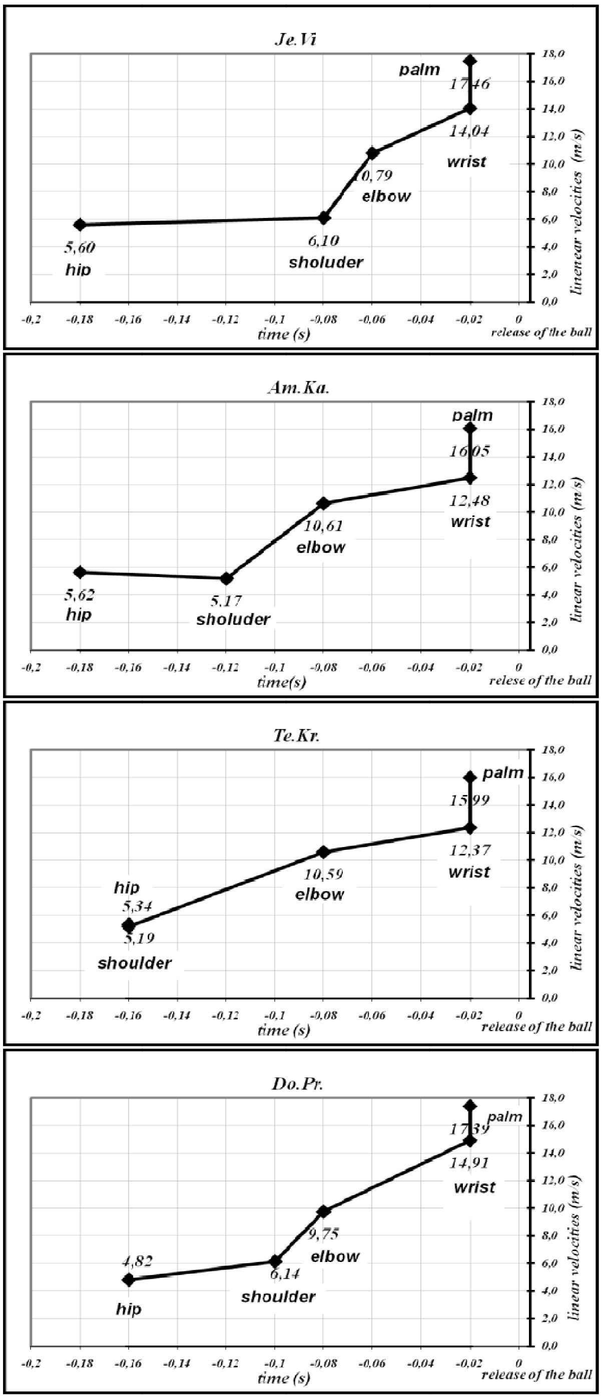

Figure 2. Maximum velocities of body segments

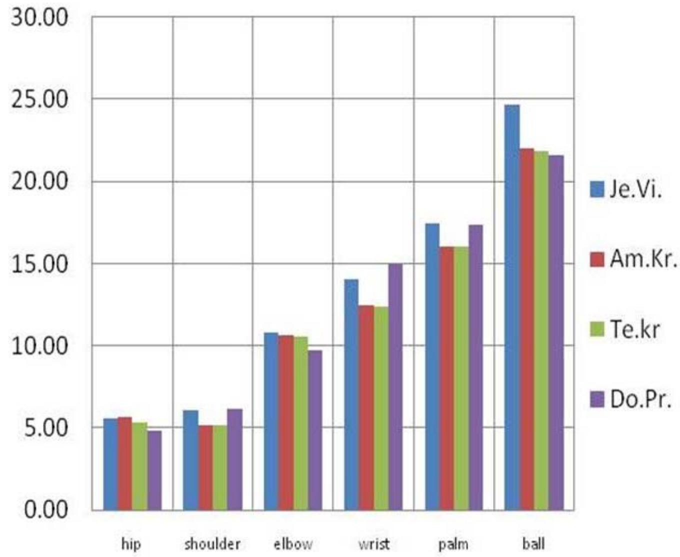

Chart 1. Linear velocities of particular body segments

Time (successive) activation of particular body segments (Table 8) was not registered for all the subjects either, namely, Te.Kr. reaches the maximum hip and shoulder velocities before the throw, at the same time point (0.16 s). A more detailed inspection of how the kinetic chain functions is possible through analysis of the particular body segments velocities in regard to the other body segments at exactly those time points. The more clear presentation of the linear velocities of particular body segments is given in the Chart 1.

These velocities specify the performance of the jump shot of each of the players, with the aim to differentiate it more clearly. It is evident that the player Je.Vi. accomplishes the velocity of the ball throw, among all activated body segments, mostly on the account of activating the last in the chain i.e. the palm. However, she reaches the highest values, in comparison to other players, in the linear elbow velocity. Do.Pr. in relation to other players, the accomplishment of relatively smaller velocities in the first segment of kinetic chain (hip), compensates with the maximum activation of the shoulder and the wrist.

The phase of the landing

An optimal landing on the take-off foot or both feet at the same time, with amortization, after which it is possible to continue moving forwards without any difficulty characterize an excellently performed landing (Pori, Bon & Šibila 2005).

Specific, automated technique of performing landing means in the case of observed players the performance of a one-foot landing on the take-off foot (Je. Vi., Te. Kr), then one-foot landing on the swing leg (Am.Ka.) and landing on both feet (Do.Pr.), whereas the height of the body’s gravity centre, at the time of the ground contact, ranges from 104.94 cm to 117.10 cm.

Conclusion

The registered kinematic parameters enable the observation of a jump shot performance with a purpose to detect the characteristics of the jump shot and then, possibly, to improve and correct the players in the process of their technical development (correcting errors), i.e., in general, they can be used as a relevant indicator for directing a future training process. Taking into account the present status of the subjects (candidates for Croatian national teams at their ages), values achieved could represent frames for successful jump shot performance in the specific age category in general, while the establishment of some model values requires further research done on the larger (representative) sample.

In future, it might be more adequate to examine the criteria for evaluating the successfulness of the jump shot performance in an actual playing situation, and then to determine how much it deviates from the correct technical performance (model comparison). Furthermore, the future research should be directed towards establishing some critical points where damaging of the locomotive apparatus involved in the performance of the shot might occur. Such research should be done respecting individual contributions the players make when creating an original "style" of performance of a particular element of a handball technique.

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USPOREDBA KINEMATIČKIH PARAMETARA IZVOĐENJA SKOK-ŠUTA RUKOMETAŠICA RAZLIČITOG UZRASTA

Sažetak

Temeljni cilj ovog istraživanja bio je analiza kinematičkih parametara za vrijeme izvođenja skok-šuta. Uzorak ispitanica se satojao od četiri rukometašice potencijalne kandidatkinje za Hrvatsku nacionalu vrstu u njihovoj kategoriji. Uzorak kinematičkih varijabli pripremljen je iz parametara povezanih sa specifičnim fazama skok-šuta i odnosio se na: pomicanje tjelesnog središta mase (CG) u vodoravnoj i okomitoj ravnini, maksimalna linearna brzina segmenata tijela i njihova vremenska aktivacija. Iz serije od sedam pokušaja, udarac s najvećom brzinom leta lopte je izabran za svaku ispitanicu i detaljno im je objašnjen svaki promatrani kinematički parametar. Moguće je koristiti registrirane kinematičke parametre za istraživanje izvršenja skok-šuta za uzorak ispitanica, sa svrhom detektiranja značajki skok-šuta. Ove mogućnosti, zatim, mogu biti upotrebljene za poboljšanje i korekciju izvođenja gibanja sportaša unutar procesa njihovog tehničkog razvoja (ispravljanje pogreški), ali se mogu promatrati i kao indikatori relevantni za upravljanje budućim trenažnim procesom općenito.

Ključne riječi: *kinematička analiza, rukometašice, skok-šut*

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