SELECTED PARAMETERS OF EXPLOSIVE STRENGTH OF YOUNG ELITE SOCCER PLAYERS

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Abstract

Relationship between muscle strength and movement realization is one of the criteria for explosive strength evaluation. Muscles are producing higher velocity of the body segment (Cabri, 1988). Better muscles coordination enables more effective increase in the movement activity with regard to its length (Zernicke, 1978). There were 11 young elite football players in this study (age 18,4±0,9 years; height 183,9±5,9 cm; weight 74,2±7,7 kg). Force platforms (Kistler, Switzerland) were used for explosive strength assessment. Kinematic analyser CODA was used for lower limb's 3D movement evaluation. The velocity of the ball was measured by radar equipment Stalker ATS. The main parameters of explosive strength during the vertical jump were: height of the jump (cm), breaking impulse (Ns^{-1}), acceleration impulse (Ns^{-1}) and time phases duration. The movement of the lower limbs and velocity of the ball were evaluated as kinematics parameters. The study confirmed that players with higher vertical jump achieved a higher speed when kicking a ball. There was a significant correlation between explosive strength of lower limbs and the speed of the ball ($r = 0{,}739$; $p < 0{,}01$). There was also a significant correlation between height of countermovement jump free arms and weight of players ($r = 0{,}812$; $p < 0{,}01$).

Keywords: explosive strength, speed of ball, soccer, dynamic.

Introduction

The aim of this study was to find if the speed of the ball during instep kick is in correlation with the explosive strength of lower limbs. Soccer is faster at the present time and players are stronger and faster. Kicking is the most widely studied skill in soccer. Although there are many variations of this skill due to ball type, ball speed and position, type and intent of kick, the variant which has been most widely reported in the literature is the maximum velocity instep kick of stationary ball. The speed of the ball is the main parameter for a football kick. The movement of the ball is given by the kicking leg during a relatively short time. Foot contact with the ball is the result of a complex coordination process (Lees and Nolan, 1998). The lower limb is producing energy which depends on muscle activity of the whole lower limb. Timing of each lower limb's segment during the movement is very important for optimal realization of the kick. There are summations of particular strengths in an ideal situation for continuous lower limb's movement. This is very important for kicking with high velocity of the ball. For good realization of this task, it is important to have the proper position of the standing lower limb and of the instep during the contact with the ball. Also, time and space process of kicking lower limb's joints is important. It means that it is a problem of strength summation rising from hip joint, to knee joint and ankle joint. This kinematics chain ends during the contact with the ball (Zahálka in Buzek et al., 2007). It would be expected that there is a relationship between muscle strength and performance, due to the fact that the muscles are directly responsible for increasing foot velocity. Such a relationship has been found by several researchers. Cabri (1988) found that there was a high correlation between knee flexor and extensor strength as measured by an isokinetic muscle function dynamometer and kick distance. Correlation coefficients between ball and foot speed reported in the literature are high ($r > 0.74$) (Asami and Nolte, 1983; Levanon and Dapena, 1998; Nunome et al., 2006a). The higher the speed of the foot before impact, the shorter the foot-ball contact and the highest the ball speed. For this reason, the ball-to-foot speed ratio has been considered as an index of a successful kick (Asami and Nolte, 1983; Kellis et al., 2004; Lees and Nolan, 1998; Nunome et al., 2006a; Plagenhoef, 1971). The effective striking mass increases as the limb becomes more rigid by muscle activation (Lees and Nolan, 1998). It was suggested (Tsaousidis and Zatsiorsky, 1996) that ball speed is affected by two factors. First factor is the energy or momentum which is a result of the co-ordinated movement and mechanical behaviour of the foot before impact. Second factor is energy which is due to muscle work produced during the collision phase. In general, this agrees with previous studies (Asami and Nolte, 1983; Bull-Andersen et al., 1999). The speed of the ball is the main biomechanical indicator of kicking success and it is the result of various factors, including technique (Lees and Nolan, 1998), optimum transfer of energy between segments (Plagenhoef, 1971), approach speed and angle (Isokawa and Lees, 1988; Kellis et al., 2004), skill level (Commetti et al., 2001; Luhtanen, 1988), gender (Barfield et al., 2002), age (Ekblom, 1986; Narici et al., 1988), limb dominance (Barfield, 1995; Barfield et al., 2002; Dorge et al., 2002; Narici et al., 1988; Nunome et al., 2006a), maturity (Lees and Nolan, 1998), the characteristics of foot-ball impact (Asai et al., 2002; Bull-Andersen et al., 1999; Tsaousidis and Zatsiorsky, 1996), muscle strength and power of the players (Cabri et al., 1988; De Proft et al., 1988; Dutta and Subramanium, 2002; Manolopoulos et al., 2006; Taina et al., 1993; Trolle et al., 1993) and type of kick (Kermond and Konz, 1978; Nunome et al., 2002; Wang and Griffin, 1997). Ball speed values reported during competition are higher compared with those found under laboratory conditions. The length, speed and angle of approach are the most important aspects of this preparatory movement which has a significant effect on soccer kick success (Isokawa and Lees, 1988; Kellis et al., 2004; Opavsky, 1988; Roberts et al., 1974). The player gets energy during the approach and together with the swing of the lower limb the energy is transferred to the ball (Isokawa and Lees, 1988). The stable position of the standing lower limb during the step, during the stretch and during the kick is one of the necessary conditions for energy transfer realization (Kellis and Katis, 2004). That is why it is necessary to know the movement pattern of the body together with the strength workings of the standing lower limb to the ground. Common description only allows evaluation of the whole movement pattern before the kick of the ball. Another important point of interest is finding the relationships between muscle strength during various isokinetics movements and quality of the kick (Masuda and Kikuhara, 2005).

1 Methods

The test group consisted of young elite football players (n=11; age 18,4±0,9 years; height 183,9±5,9 cm; weight 74,2±7,7 kg). All players realize training 4-5 times per week and their football experience is in average 11,5 years. Their technical level of football skills is at high level and it is comparable to the adult players. All players realized seven instep kicks with maximal strength. The main task was to achieve the maximal speed of the kicked ball. The position of the standing ball was the same for all players; the position for starting the approach was set individually. Contact of the standing lower limb was situated on the force plate KISTLER. Movement of the player was evaluated by on-line 3D kinematics analyser

CODA Motion. The sensors were placed on the selected parts of the lower limb (on football boots - it was on position approximately where there is 5th metatarsus and heel; next positions were on the ankle, on the fibula, on the knee and on the hip where big trochanter is). Both measurement units were synchronized together with the sampling frequency of 400 Hz. The speed of the kicking ball was measured by radar equipment STALKER ATS. Body composition of the players was evaluated by bio-impedance method with the NUTRI 4 software. For evaluating explosive strength, measurement of vertical jump was used. All players absolved 4 attempts of vertical jump with help of arms – countermovement jump with free arms. For measurement of the force during the jump, take-off velocity and height of the jump the software BioWare was used.

Tab. 1 General parameters of players

Name	**Age**	**tall**	**weight**	**ECM/ /BCM**	**%fat**	**FFM**	**Position**
	years	cm	kg		%	kg	
Player01	18 (92)	185	82	0,73	11,3	73,2	goalkeeper
Player02	19 (91)	191,4	86,9	0,74	11,7	76,7	
Player03	19 (91)	178,8	71,2	0,72	10,1	64	
Player04	19 (91)	179,2	69,5	0,77	9,5	62,9	
Player05	19 (91)	174,5	60	0,61	7,3	56,4	
Player06	18 (92)	192	82	0,73	10,6	74,2	goalkeeper
Player07	16 (94)	189	66	0,83	7,9	60,9	goalkeeper
Player08	19 (91)	191,3	80,3	0,77	9,6	72,6	goalkeeper
Player09	19 (91)	182,6	75,9	0,63	10,6	67,8	
Player10	18 (92)	177,2	68,9	0,71	9,8	62,2	
Player11	19 (91)	182	73,5	0,64	9,8	66,3	

FFM – free fat mass

2 Results

The main parameters for evaluation of movement pattern were: the velocity of the kicked ball, the time of lower limbs contact with the ground and its force. The force of the standing lower limb to the ground is consequently recalculated to the quiet force of the player during the standing (weight of the player). It is necessary for force objectification because heavier players produce higher force than the lighter ones. The next evaluation parameter was length of the last step. It is length between the heel of the kicking right lower limb at the moment of the last contact with the ground and heel of the left standing lower limb at the moment of the first contact with the ground. The velocity of the point on the hip was used for evaluation of the speed of approach. Maximal velocity of the approach was measured at the moment of the last contact of the kicking right lower limb with the ground. The next evaluation parameter was standing position of left standing lower limb against the ball. This length was calculated as the difference between the standing lower limb's heel position and the position of the ball's centre (position where the ball in contact with the ground is). All players realized the kick from the same place.

Tab. 2 Measured parameters of players

Players	weight	Ball speed IK	Step time IK	Force IK	Force/kg	Last step IK	Speed LS IK	Position of support leg IK	CMJFA
	kg	km/hour	s	N	N	mm	m/s	mm	m
Player01	82	106,5	0,7025	2613,1	31,87	1528,5	4,173	378,3	0,4866
Player02	86,9	107,4	0,2225	3057	35,18	1395,8	3,787	440,8	0,4944
Player03	71,2	93,9	0,3075	2723,2	38,25	1385,3	3,82	326	0,4089
Player04	69,5	101,5	0,31	2697	38,81	1267,5	3,923	328,4	0,4341
Player05	60	101,2	0,21	1973,2	32,89	1265,9	4,26	396,9	0,4196
Player06	82	104,1	0,2025	3080	37,56	1503	4,105	493,4	0,4866
Player07	66	98,9	0,28	2390,1	36,21	1690,2	4,44	434	0,3949
Player08	80,3	103,6	0,57	2090,8	26,04	1563,2	3,865	399,4	0,4341
Player09	75,9	102,1	0,2425	2426,4	31,97	1218,8	3,118	573,2	0,4828
Player10	68,9	99,5	0,2225	1827,9	26,53	1079,6	3,383	422,1	0,4089
Player11	73,5	94,8	0,2025	2486,8	33,83	1210	3,72	291,7	0,4341
avg	**74,20**	**101,23**	**0,32**	**2487,77**	**33,56**	**1373,44**	**3,87**	**407,65**	**0,44**
SD	**7,70**	**4,09**	**0,16**	**388,56**	**4,12**	**175,18**	**0,36**	**76,40**	**0,03**
var	**26,90**	**13,50**	**0,50**	**1252,10**	**12,77**	**610,60**	**1,32**	**281,50**	**0,10**

IK – instep kick, LS – left side, CMJFA - countermovement jump free arms

There was significant correlation between explosive strength of lower limbs and speed of the ball ($r = 0,739$; $p < 0,01$). Explosive strength of lower limbs is important for speed of ball.

There was also significant correlation between height of countermovement jump free arms and weight of the players ($r = 0,812$; $p < 0,01$). Our players had significant correlation between weight and free fat mass ($r = 0,996$; $p < 0,01$) and free fat mass is in high correlation with countermovement jump free arms ($r = 0,811$; $p < 0,01$).

There was correlation between speed of approach and the length of the last step ($r = 0,699$; $p < 0,05$), along with this was find high correlation between players tall and length of the last step ($r = 0,726$; $p < 0,05$), but there is low correlation between speed approach and the ball speed ($r = 0,118$; $p > 0.05$).

There was correlation between players weight and force produced by standing lower limb to the ground ($r = 0,615$; $p < 0,05$), but we didn't find any correlation between force produced by standing lower limb to the ground and the ball speed ($r = 0,263$; $p > 0,05$).

3 Discussion

If we compare our results to the world literature, we could see that the ball speed in our research was almost the same. Nunome and Ikegami (2002) measured instep kick on five high school elite players (exact age wasn't mentioned). In this study the speed of the ball was 28±2,4 m.s-1 (100,8 km/hour), in our study the speed of the ball was 101,23±13,50 km/hour. The most similar study to ours is Taina (1993), where there was tested 15 players with average age of 18,1 years. Taina (1993) had ball speed 96,02 km/hour, it's lower than in our study. For example, Nunome (2006) had 9 older players in the research. Their average age was 27,6 years with the ball speed 26,3±3,4 m/s (94,68 km/hour). Players in our study are on high level in physical strength and technique, but they aren't on elite level. Cometti (1988) measured the ball speed of professional players at 106,37±12,89 km/hour.

Our players has lower countermovement jump free arms in comparison with basketball players, for instance; in the study (Ziv and Lidor 2010) there are values of T1 h= 0.61 m, T2 h = 0.439 m and T3 h = 0.398 m.

Conclusion

Our research further proved the importance of developing explosive strength in soccer. Development of explosive strength improves not only the speed skills, but also the speed of the ball. Another disposition for higher explosive strength of lower limbs is the ideal weight with a high proportion of muscle mass due to the weight of the player. Length of the last step depends on the speed of approach and height of player, but is not critical for speed of ball.

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VYBRANÉ PARAMETRY VÝBUŠNÉ SÍLY U MLADÝCH ELITNÍCH FOTBALISTŮ

Většina pohybových činností ve sportovních hrách je prováděna pomocí dolních končetin a jejich činnost je i podmínkou pro účinný a efektivní pohyb hráče během utkání.Jedním z kritérií pro hodnocení explosivní síly je vztah mezi silou svalstva a provedeným pohybem, a to tak, že svaly jsou přímo odpovědné za vzrůstající rychlost (Cabri, 1988). Dokonalejší svalová koordinace umožňuje účinnější průběh rychlostní činnosti, zejména frekvenčního charakteru, a její delší trvání (Zenricke, 1978). Pro studii bylo využito 11 hráčů vrcholové úrovně (věk 18,4±0,9; výška 183,9±5,9 cm; váha 74,2±7,7 kg). Pro hodnocení explozivní síly dolních končetin při vertikálním výskoku bylo využito silových desek (Kistler, Switzerland). Pro evaluaci vnějších projevů síly při švihu dolní končetiny během kopu do míče bylo využito on-line prostorového kinematického analyzátoru CODA Motion.

AUSGEWÄHLTE PARAMETER DER SPRUNGKRAFT VON JUGENDLICHEN ELITEFUSSBALLSPIELERN

Die meisten Bewegungstätigkeiten in Sportspielen werden mit Hilfe der unteren Gliedmaßen durchgeführt und ihre Tätigkeit ist zugleich die Bedingung für eine wirkungsvolle und effiziente Bewegung des Spielers beim Match. Eines der Kriterien für die Bewertung der explosiven Kraft ist das Verhältnis zwischen der Kraft der Muskulatur und der durchgeführten Bewegung und zwar so, dass die Muskeln für die sich erhöhende Geschwindigkeit direkt verantwortlich sind (Cabri, 1988). Eine perfektere Muskelkoordination ermöglicht einen effektiveren Verlauf der Geschwindigkeitstätigkeit, besonders der Geschwindigkeitstätigkeit von Frequenzcharakter, und auch ihre längere Dauer (Zenricke, 1978). Für die Studie wurden 11 Spieler von Spitzenniveau untersucht (Alter 18,4± 0,9 Jahre, Größe 183,9± 5,9 cm, Gewicht 74,2 ± 7,7 kg). Für die Bewertung der explosiven Kraft der unteren Gliedmaßen bei vertikalem Absprung wurden Kraftsensoren benutzt (Kistler, Schweiz). Für die Evaluation von äußeren Krafterscheinungen beim Schwung der unteren Gliedmaßen während des Ballstoßes wurde der kinematische Raumanalysator CODA Motion online benutzt.

WYBRANE PARAMETRY SIŁY EKSPLOZYWNEJ U MŁODYCH ELITARNYCH PIŁKARZY

Większość czynności ruchowych w grach sportowych wykonywana jest przy pomocy kończyn dolnych a ich aktywność stanowi także warunek skutecznego i efektywnego ruchu gracza w trakcie meczu. Jednym z kryteriów oceny siły eksplozywnej jest stosunek pomiędzy siłą mięśni a wykonanym ruchem, przy czym mięśnie są bezpośrednio odpowiedzialne za rosnącą szybkość (Cabri, 1988). Doskonalsza koordynacja mięśni umożliwia skuteczniejszy przebieg szybkiej czynności, szczególnie o charakterze frekwencyjnym, oraz jej dłuższy czas trwania (Zenricke, 1978). Badania przeprowadzano na 11 graczach wyczynowych (wiek 18,4±0,9; wysokość 183,9±5,9 cm; waga 74,2±7,7 kg). Do oceny siły eksplozywnej kończyn dolnych przy wyskoku pionowym wykorzystano płyty siłowe (Kistler, Szwajcaria). W ewaluacji zewnętrzych objawów siły przy wykopnięciu kończyny dolnej w czasie kopnięcia w piłkę wykorzystano on-line przestrzenny kinematyczny analizator CODA Motion.