Trakia Journal of Sciences, No 3, pp 221-226, 2022

Available online at:
http://www.uni-sz.bg

ISSN 1313-3551 (online) doi:10.15547/tjs.2022.03.008

Original Contribution

CORRELATION OF THE BALL SPEED AND RELATIVE STRENGTH POTENTIAL AND EXPLOSIVE POWER OF THE LOWER LIMBS OF IN-STEP KICK OF ELITE FOOTBALL PLAYERS

M. Gadev, P. Peev*

National Sports Academy "Vassil Levski", Track and Field Department, Sofia, Bulgaria,

ABSTRACT

The purpose of this study was to reveal the significance of the strength component of major muscle groups and explosive power of lower limbs of elite football players in relation to ball speed upon execution of in-step kick. **Methods** The research was done among 42 football players aged between 18 and 19 years. The following methods were used: speed metric, tensometry, and dynamometry. The data were processed with math-statistical methods (descriptive statistics and correlation analyses). **Results** The structural interdependencies between different indicators influencing ball speed were revealed. The data analysis established a strong direct ratio correlation dependence between ball speed and the relative strength of hip muscles of left and right legs (r=0,703 and r=0,720 respectively). We found that the strength component affecting ball speed was more significantly influenced by the relative strength of the muscles of the hip flexors and less influenced by those of the hip extensors. There was a strong interdependence with speed-strength abilities which are related to the magnitude of the power.

Conclusions All in all, we believe that the revealed specifics and guidelines for strength and explosive power influence in conditional training sessions will help increase ball speed upon execution of in-step kick.

Key words: football, shooting, interdependence

INTRODUCTION

The in-step kick is the main means for scoring goals from a larger distance and for long-range passes in football. This fact makes it both an important and an interesting subject of research for sports specialists. The literature review we made showed that the issue related to ball speed upon execution of in-step kick was linked to a great extent to the anatomical and biological problems related to football players' technical skills (1-8).

Another group of researchers directed its attention to revealing the influence of anthropometric and some explosive power indicators on ball speed (9-19). All of those contributed to determining the above-mentioned factors related to ball speed upon execution of in-step kick. We should certainly point out that the thing which unites all the factors is players' technical skills. In this sense, we should mention that efficient technique is supported by a high enough level of conditioning (20-23). It is well known that the latter lead to building proper motor skills as regards kinematics and dynamics of the execution of the in-step kick in football. As a continuation of all the surveys done on the topic, we would like to add and broaden the theoretical knowledge in this field.

***Correspondence to:** *Petar Peev, National sports academy "Vassil Levski", Track and field department, Sofia, Bulgaria, Sofia, Bulgaria, str. "Academic Stefan Mladenov" 21, e-mail: petar.r.peev@gmail.com, GSM: +359 878 354911*

The aim of this research was to optimize the strength and conditioning part of sports training by revealing the significance of the strength component of the major muscle groups and the explosive power of the lower limbs of elite football players in relation to ball speed.

To fulfill the aim, we set the following tasks:

- Surveying ball speed in relation to the execution of the in-step kick
- Surveying the relative strength potential of major muscle groups of lower limbs
- Determining the interdependencies of ball speed upon execution of in-step kick and the relative strength and explosive power potential of lower limbs.

MATERIALS AND METHODS

In order to fulfill the above-mentioned tasks, we used several sports-pedagogical tests and indicators **(Table 1).**

Table 1. *Test and indicator used in the research*

№	Tests and Indicators	Measurement unit	Accuracy
1.	Maximal ball speed of in-step kick	km/h	1
2.	Relative strength (flexors) of muscles around the ankle joint **(RSFMAJ – left leg)**	kg/weight	0.01
3.	Relative strength (extensors) of muscles around the ankle joint **(RSEMAJ – left leg)**	kg/weight	0.01
4.	Relative strength (flexors) of muscles around the ankle joint **(RSFMAJ – right leg)**	kg/weight	0.01
5.	Relative strength (extensors) of muscles around the ankle joint **(RSEMAJ – right leg)**	kg/weight	0.01
6.	Relative strength of the muscles of the hamstring **(RSMH – left leg)**	kg/weight	0.01
7.	Relative strength of the muscles of the hamstring **(RSMH – right leg)**	kg/weight	0.01
8.	Relative strength of hip muscles **(RSHM – left leg)**	kg/weight	0.01
9.	Relative strength of hip muscles **(RSHM – right leg)**	kg/weight	0.01
10.	Mean height of the jump of all the 5 jumps – (**h_m**)	cm	0.1
11.	Mean time of the support of all the 5 jumps– (**t_{sup}**)	s	0.001
12.	Coefficient of explosiveness of all the 5 jumps – (**$К_{exp}$**)	cm/s	0.001

The measurement of ball speed upon execution of in-step kick (Test 1) was made with radar system "Speedchek" (SCX-01, Tribar Industries Inc., Ontario, Canada) with the following technical characteristics: Maximal measured speed - 199 km/h; Range – at least 10 m; Accuracy ± 2-3 km/h; Measurement zone – 60º along the vertical axis and 40º along the horizontal axis.

The requirement is that the radar device should be placed behind the goal net, and the player should be positioned within at least 10 m directly in front. Thus, we can ensure that ball speed is recorded exactly the moment after the kick and the radar system is not activated by the limb movements. The kick is executed without a goalkeeper to avoid the external factors affecting its strength. Three kicks are performed, and the highest value of the technically correct kick is recorded. Each player performs in turn (the order is preliminarily set) which is a premise for a complete recovery before each kick. The research is preceded by a standard warm-up.

The measurement of the relative local strength of lower limbs in an isometric regime was made with a tensometric beam and an enhancing and transforming device recording strength equivalent.

The strength equivalent of the different muscle groups was measured with Tests 2, 3, 4, 5, 6, 7, 8, and 9. When the strength of the muscles around ankle joint is measured (Tests 2 and 4 – muscles

flexors of the ankle joint of left and right leg, and Tests 3 and 5 – muscles extensors of left and right leg), the researched individual should be in sitting position; the thigh and lower leg are square. The right angle is ensured with the use of a special chair with the regulation of the height and change in the position of the horizontal heaver. Hands are on the thighs. The measuring device for Tests 2 and 4 is placed on the thigh just above the knee cap. The maximal pressure is ensured by raising the foot on toes until reaching the position pointed toes. When the measurements for Tests 3 and 5 are made, the device is lowered along the vertical heaver and is placed on the upper part of the foot. The extension of the ankle joint is done by maximum raising the front part of the foot (toes) until failure. After the data are recorded, we switch to the other foot.

The measurement of the hamstring strength (Tests 6 and 7 – left and right leg respectively) is made from a standing position. The researched individual stands with his back to the horizontal bar. The heel is placed at the bottom of the device, and exerts pressure upward through knee joint flexion towards the thigh. The hands are placed on a special lever to ensure balance during the test.

When the strength of the hip muscles is measured (Tests 8 and 9 – left and right leg respectively), the researched individual stands facing the vertical bar so that the projection of center of gravity be slightly in front of the toes. Balance is ensured by placing the hands on the above-mentioned lever (Tests 6 and 7). The upper part of the toes is placed below the device; knees are slightly bent. The thigh is raised vertically upwards with maximum exertion until failure. The results are recorded, and the foot is switched without changing the initial position.

To measure the anthropometric indicator weight, needed for establishing the relative strength of the muscle groups, we used medical scales (Seca-213, SECA, Leicester, UK).

The explosiveness of lower limbs in the vertical plane was examined with the test 5 vertical jumps on the platform with raising knee joints towards the chest. We recorded the results with a Digital jump counter (ЦОМ-2, Sofia, Bulgaria which contains a microprocessor system with printing device measuring jumps with heights from 0.1 cm to 125 cm, and the number of the jumps – from 1 to 50), where: indicator № 10 – $\mathbf{h_m}$ (mean height of the jump in all the 5 jumps); indicator № 11 – $\mathbf{t_m}$ (mean time of supports in s of all the 5 jumps), and indicator № 12 – $\mathbf{K_{exp}}$ (coefficient of explosiveness of lower limbs, which is automatically calculated with the formula $\mathbf{K_{exp}=h_m}$cm/$\mathbf{t_m}$s). The measurement of the last one is made in a lab. The methodological guidelines for the jump are that it should be performed with a maximum height and a maximally short time of support on the platform.

In order to process the results from the surveys, we used the statistical methods variation and correlation analyses.

The research was done among 42 (182,8 cm; 78,6 kg) elite football players (aged between 18 and 19 years) with at least 5 years of sports and training experience.

RESULTS

The results obtained from variation analysis of the data about the relative strength and explosive power potential of lower limbs and ball speed (elite football players) are presented in **Table 2**.

We can see that the mean values for the relative strength of the muscle flexors of the ankle joint of left and right leg (Tests 2 and 4) were close, i.e., there was no disproportion in their development. The same can be said about the rest of the tests characterizing the strength component of the lower limbs. We should also pay attention to the higher mean values of the relative strength of hip muscles (Tests 8 and 9) as regards the values of the relative strength of hamstring (Tests 5 and 6). Obviously, the first ones are important for the acceleration of the mass of the kicking leg and, as a whole, for creating a greater impulse of its strength. We could expect that its higher values would facilitate this. The data showed that the coefficient of variation was within V – 5,39 % and V – 16,11 % . This allows us to summarize that there was homogeneity in the researched sample of football players, and therefore we can make certain conclusions.

Table 2. *Variability of the indicators of the relative strength and speed-strength potential of lower limbs and ball speed*

Statistical indicators ⇩	**Researched indicators ⇩**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
x	**104,25**	**1,88**	**0,51**	**1,93**	**0,50**	**0,49**	**0,53**	**0,58**	**0,61**	**32,03**	**0,172**	**1,873**
m_x	1,98	0,07	0,02	0,11	0,02	0,01	0,02	0,02	0,02	1,47	0,003	0,06
S	5,62	0,21	0,06	0,31	0,07	0,04	0,05	0,06	0,06	4,17	0,01	0,18
Ex	-0,14	-0,30	-0,37	-0,58	-0,69	-0,53	-1,56	0,24	0,52	-1,01	0,58	-0,14
As	1,19	0,68	-0,92	0,69	-0,67	0,58	-0,29	-0,33	-1,13	-0,23	-0,72	-0,62
R	15	0,64	0,17	0,87	0,21	0,14	0,14	0,20	0,17	12,3	0,035	0,534
x_{min}	99	1,59	0,41	1,58	0,38	0,43	0,45	0,47	0,50	25,4	0,151	1,552
x_{max}	114	2,23	0,58	2,45	0,59	0,57	0,59	0,67	0,67	37,7	0,186	2,086
V %	5,39	11,40	11,84	16,11	15,04	9,38	9,91	10,89	9,51	13,04	6,56	9,79

To reveal the interrelations between the different strength and explosive power indicators with speed ball in execution of in-step kick, we performed a correlation analysis. The values of the correlation coefficients are presented in **Table 3.**

Table 3. *Correlation dependence of the tests and parameters of the relative strength and explosive power potential of lower limbs with ball speed*

Indicators ⇩ ⇨	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	**xxx**										
2	0,468	**xxx**									
3	0,337	-0,232	**xxx**								
4	0,446	0,802	-0,469	**xxx**							
5	0,370	0,185	0,301	0,087	**xxx**						
6	0,464	0,514	0,338	0,523	0,469	**xxx**					
7	0,479	0,543	0,376	0,502	0,305	0,310	**xxx**				
8	0,703	0,131	0,409	0,211	0,414	0,558	0,580	**xxx**			
9	0,720	0,237	0,487	0,080	0,404	0,565	0,597	0,812	**xxx**		
10	0,758	0,203	0,380	0,192	0,446	0,388	0,210	0,395	0,464	**xxx**	
11	0,471	0,361	0,249	0,392	0,471	0,133	0,318	-0,525	-0,572	0,513	**xxx**
12	0,572	0,404	0,373	0,488	0,389	0,466	0,420	0,327	0,388	0,844	0,324

DISCUSSION

The analysis of the data from the correlation matrix shows a strong direct ratio correlation dependence between ball speed and the relative force of hip muscles of the left and right leg (r=0,703 and r=0,720, respectively). This means that the higher values are a premise for a greater ball speed upon execution of in-step kick among the researched football players. Obviously, these muscle groups play an important role in the acceleration of the swinging (kicking) leg. We established such a high correlation dependence between the above-mentioned muscle groups of the left and right leg (r=0,812). This fact confirms the significance of the development of strength component for ball speed.

When tracing the interrelation of ball speed and the other indicators characterizing the strength component, we can see that the values of the relative strength of the muscle flexors around the ankle joint of the left leg (Test 2) and right leg (Test 4) are in a direct and relative ratio correlation with it (r=0,468 and r=0,446,

respectively). We also established a direct and moderate dependence with the values for the relative strength of the muscle extensors around the ankle joint of the left leg (Test 3) and right leg (Test 5) but the values were lower (r=0,337 and r=0,370, respectively). This allows us to claim that ball speed increases to a greater extent due to the higher values of the relative strength of muscle flexors and to a less extent due to the muscle extensors. Obviously, in the development of strength components, some means influencing the relative strength of muscle flexors around the ankle joint should be selected.

We established a significant relation (Test 12) between ball speed and the indicator characterizing explosive power (r=0,572). It is interesting to point out that the coefficient of explosiveness is strongly influenced (r=0,844) by the indicator of the height of the jump (Test 10). We link the last one with the magnitude of the power. As regards the indicator of time (Test 11) which determines the coefficient of explosiveness, there was a strong reverse dependence with the relative strength of hip muscles of the left and right leg (r= -0,525 and r= -0,572, respectively). These data make us suggest that the increase of the strength component of the last ones would enable the reduction of time during support period. This, as a whole, would lead to an increase in the coefficient of explosiveness of lower limbs. And, as we mentioned earlier, it is in a strong interrelation with ball speed.

The data show that the relative strength of the researched muscle groups should be not only increased but also transformed into explosive manifestation upon execution of in-step kick. This transformation is seen in the acceleration of the mass of the swinging (kicking) leg. This, as a whole, will facilitate the higher impulse of the force of the kick, and consequently it will add to the greater ball speed. In this sense, we consider it would be suitable to use strength and explosive power exercises of different resistance. We would recommend the inclusion of different types of machines, gym bands, or resistance bands into the training process.

The analysis of the interrelations between the indicators characterizing the relative strength potential of lower limbs showed a strong relation between hamstring muscles (Tests 6 and 7) and hip muscles (tests 8 and 9). The direct ratio suggests that the higher the strength component of the relative strength of hamstring muscles, the higher the relative strength of the hip muscles. The latter, as we mentioned above, is of great significance for increasing the speed of movement of the swinging leg performing the kick, and hence – ball speed.

We established such a strong direct ratio dependence between the relative strength of hamstring muscles (Tests 6 and 7) and the relative strength of muscle flexors around ankle joint (Tests 2 and 4). These dependencies show a certain synergism and significance of the technical execution of this kind of kick.

CONCLUSIONS

In conclusion, we could say that the level of development of muscle groups contributing to the acceleration of the swinging (kicking) leg is important for ball speed upon execution of an in-step kick. In this sense, the level of the strength component of the relative strength of hip muscles is the most important. Of course, in the overall execution there is a strong synergic help on behalf of the different segments of lower limbs – hamstring muscles and muscle flexors around the ankle joint. To realize this strength potential, it should be transformed into explosive manifestation (power) of the force imparted in the kick.

REFERENCES

1. Gadev, M., Tishinov, O and Mardov, I., Relationship between ball speed and some biomechanical indicators of execution of in-step kick of low-qualified football players, *Sport and science*, 3: 9-15, 2001
2. Dörge, H. C., Andersen, T. B., SØrensen, H., and Simonsen, E. B., Biomechanical differences in soccer kicking with the preferred and the non-preferred leg. *Journal of sports sciences*, *20*(4): 293-299, 2002.
3. Young, W., Clothier, P., Otago, L., Bruce, L. and Liddell, D., Acute effects of static stretching on hip flexor and quadriceps flexibility, range of motion and foot speed in kicking a football. *Journal of Science and Medicine in Sport*, *7*(1): 23-31, 2004.
4. Markovic, G., Dizdar, D. and Jaric, S., Evaluation of tests of maximum kicking

performance. *Journal of sports medicine and physical fitness*, *46*(2): 215-220, 2006.

5. Rodríguez-Lorenzo, L., Fernandez-del-Olmo, M. and Martín-Acero, R., A critical review of the technique parameters and sample features of maximal kicking velocity in soccer. *Strength & Conditioning Journal*, *37*(5): 26-39, 2015.
6. Bekris, E., Gioldasis, A., Bekris, V., Gissis, I., Komsis, S. and Mitrousis, I., The relationship of kicking bal. velocity with anthropometric and physiological factors in soccer. *Sport Science Review*, *24*(1-2): 71-87, 2015.
7. García-Pinillos, F., Ruiz-Ariza, A., Moreno del Castillo, R. and Latorre-Román, P. Á., Impact of limited hamstring flexibility on vertical jump, kicking speed, sprint, and agility in young football players. *Journal of sports sciences*, *33*(12): 1293-1297, 2015.
8. Takahashi, S., Kawamoto, R., Kato, S., Saho, Y., Hirose, N. and Fukubayashi, T., Hip kinematics and muscle activity during inside soccer kick in players with a history of groin pain. In *ISBS-Conference Proceedings Archive*, *November*, 34(1): 371-374,2016.
9. Manolopoulos, E., Papadopoulos, C., Salonikidis, K., Katartzi, E. and Poluha, S., Strength training effects on physical conditioning and instep kick kinematics in young amateur soccer players during preseason. *Perceptual and motor skills*, *99*(2): 701-710, 2004.
10. Apriantono, T., Nunome, H., Ikegami, Y. and Sano, S., The effect of muscle fatigue on instep kicking kinetics and kinematics in association football. *Journal of sports sciences*, *24*(9): 951-960, 2006.
11. Masuda, K., Kikuhara, N., Takahashi, H. and Yamanaka, K., The relationship between muscle cross-sectional area and strength in various isokinetic movements among soccer players. *Journal of sports sciences*, *21*(10): 851-858, 2003;
12. Cerrah, A. O., Gungor, E. O., Soylu, A. R., Ertan, H., Lees, A. and Bayrak, C., Muscular activation patterns during the soccer in-step kick. *Isokinetics and Exercise Science*, *19*(3), 181-190, 2011.
13. Young, W. B., and Rath, D. A., Enhancing foot velocity in football kicking: the role of strength training. *The Journal of Strength & Conditioning Research*, *25*(2): 561-566, 2011;
14. Noguchi, T., Demura, S. I. and Nagasawa, Y., Relationship between ball kick velocity and leg strength: A comparison between soccer players and other athletes. *Advances in Physical Education*, *2*(03): 95-98, 2012:
15. Brahim, M. B., Bougatfa, R. and Mohamed, A., Anthropometric and physical characteristics of Tunisians young soccer players. *Advances in Physical Education*, *3*(03): 125, 2013.
16. Rodríguez-Lorenzo, L., Fernandez-del-Olmo, M. and Martín-Acero, R., Strength and Kicking Performance in Soccer: A Review. *Strength and Conditioning Journal*, *38*(3), 106-116, 2016.
17. Gadev, M. and Peev, P., Correlation between power potential, anthropometry and the speed of the ball of in-step kick in football. Proceeding book, "International scientific conference Effects of applying physical activity on anthropological status of children, adolescents and adults", Belgarade: 171-177, 2018.
18. Gadev, M. and Peev, P., Age related differences and evaluation of the ball speed of in-step kick in football, Proceeding book of the International Congress "Applied Sports Sciences", 15-16 November 2019, Sofia NSA Press, 133-136, 2019. // ISBN: 978-954-718-601-9
19. Peev, P. And Gadev, M., relationship between relative strength potential of the lower limbs and ball speed of in-step kick of low-qualified football players. *Track and field and science*, *1*(19): 66-71, 2019.
20. Koloskov, V., Urgent tasks. *In Football (Yearbook)*, Moscow, Physical education and Sport, 4-5, 1981.
21. Bachvarov, M., Strength and conditioning of the football player, *NSA- PPB*, Sofia, 1992 //
22. Korenberg, V., Basics of sports kinesiology, *Soviet sport*, Moscow, 2005
23. Selyanov, V., Sarsania, V., and Zaborova, V, Football: problems of the physical and tehnical preparation, Dolgoprudny. INTELLEKTiK, 2012