Trakia Journal of Sciences, Vol. 19, Suppl. 1, pp 861-866, 2021
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Available online at:
http://www.uni-sz.bg

ISSN 1313-3551 (online) doi:10.15547/tjs.2021.s.01.135

KICKING AND ITS BIOMECKANICAL CHARACTERISTICS IN RUGBY

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ABSTRACT

The study features a biomechanical analysis of kicking the ball in rugby. Although rugby has a long history, it is understudied in our country. When taking a place kick in the game, the ball should achieve its maximum speed. The skills of place kicking are unique because of the specific shape of the ball, the use of kicking tee, and the angles of the swing. Here we shall explore this proximal-distal sequence aka the combined speed principle with the outcome of reaching maximum ball speed, which requires maximum speed of the foot prior to the contact with the ball.

Key words: kinematics; kicking, striking; follow-through motions, velocity, speed

INTRODUCTION

Most of the motions in passing/throwing/pitching and kicking include a kinetic series that begins with the proximal segments and continues to the distal segments. This principle, also known as proximal-distal consistency or the principle of additive velocity, is seen in certain motions (pitching in baseball, swinging in golf, put shooting, and kicking in soccer) whose goal is to reach maximum ball velocity, which requires reaching maximum leg (or arm) velocity before contact with the ball.

Although rugby is not a new sport, it is poorly studied in our country. When taking a place kick during the game, the ball should achieve its maximum speed. Just like kicking the ball with your inner foot in a soccer game, place kicking in rugby involves a series of motions aimed at the rugby ball, placing the non-kicking foot next to the ball and striking the ball with your inner foot.

Even though the kicking patterns in soccer and rugby are basically similar, the place kicking technique in rugby is unique due to the shape of the ball, the use of a kicking tee, and the swinging angles. (1-5)

The number of biomechanical studies in rugby place kicking techniques is quite limited. The two-dimensional analysis done by Acheson and Lees in 1983 shows that the effect of two-phase acceleration of the foot is good enough. The first phase occurs due to the fall of the lower leg against gravity, and the second phase arises from the interaction between the segments at the top and bottom of the leg. In 2007, Bezodis et al. investigated the non-kicking-side arm motion during rugby place kicking. They found that longitudinal angular momentum of non-kicking-side arm might increase the accuracy in maximum distance kicking. Studies of kicking in soccer have also shown that the velocity of the ball is affected by rotation along the longitudinal axis of the pelvic segments (Lees and Nolan, 2002). (6-11)

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In summary, from a kinematics point of view, the speed of the striking foot depends not only on the most peripheral (distal) segments, but also on other proximal segments. Ball kicking is accordingly a combination of segmental and joint rotations in multiple planes following a proximal-distal sequence to achieve maximum foot velocity, and hence maximum initial speed of the ball. Any researches in rugby place kicking so far never included studies of the other body segments. Studying the contribution of different body segments to the kicking foot will help us understand the role of each of these segments during the kick, compare the performance of different groups of athletes, and possibly to set up a scientific basis for improving these performances. For example, there are contradictive training methods - some coaches argue that when kicking the ball, the body should be carried back, other coaches point out that in the moment of striking, the head should go over the ball. (12-15)

METHODS

Collected data

Four experienced kickers, i.e. two male and two female from players from the National Sports Academy rugby teams participated in the present study. Filming was performed in 2D dimension with a CASIO ZR500 camera placed on a tripod perpendicular to the plane of striking the ball.

The initial speed is computed by observing the moment the ball leaves the ground shot at 120 frames per second. The kinematic analysis was performed with the open access professional software application SkillSpector. The analysis of the take-off angle of the ball was performed with an electronically placed angle meter on the observed motion pattern. **/Figure 1/**

Figure 1.

The effectiveness of kicking depends on the technical skill of the rugby player. According to the laws of biomechanics, maximum distance and maximum height are achieved at a take-off angle of 45 degrees. Because of the anatomical features of the athletes, they performed the kicks under comfortable conditions with an average of 51 degrees and corresponding maximum and minimum values within the statistical sample studied. In order to achieve maximum velocities, which through the law of conservation of quantity of motion translate into the actual velocity of the ball, one must synchronize for a simultaneous increase in force impulses at the control points located on the foot, ankle, knee, and hips. Since the momentum of the force is equal to the amount of motion $F \times t = m \times V$ then if all the listed impulses adequate to the amount of motion increase, the outermost segment of the body, in this case the foot, will also acquire a maximum value and the foot will produce a maximum velocity to the ball. A reference diagram of the instantaneous velocities of the described points on the athlete's body is given to illustrate this sequence.

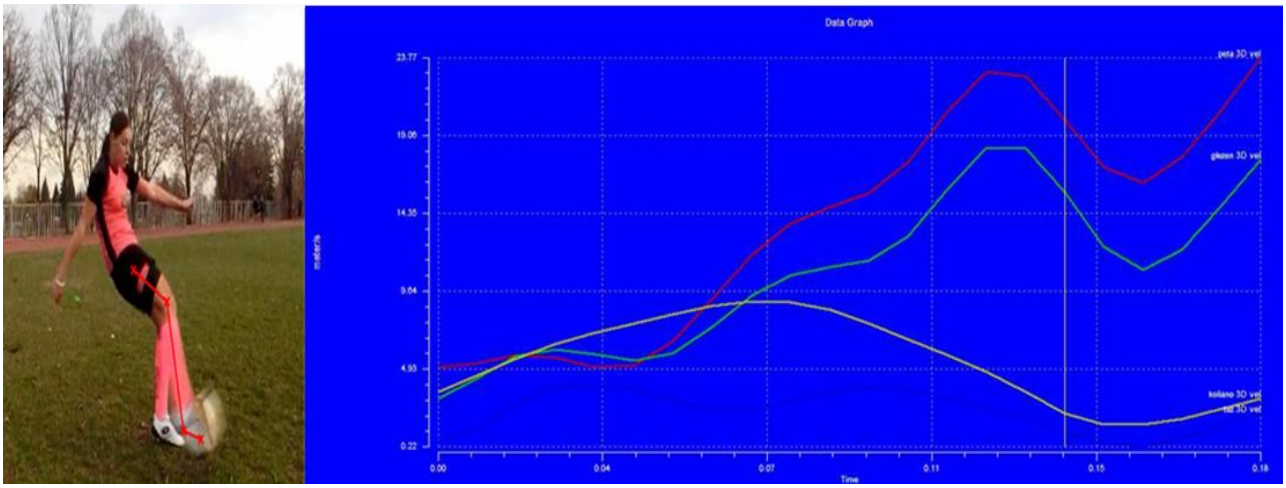

Figure 2.

Figure 2 shows the heel, ankle, knee, and hip trajectories, which is not clearly visible because of the blue background colour. The hip velocity has the lowest value.

To indicate the areas that are relevant to produce maximum speed, a frame is placed on the speed graph, shown in **Figure 3.**

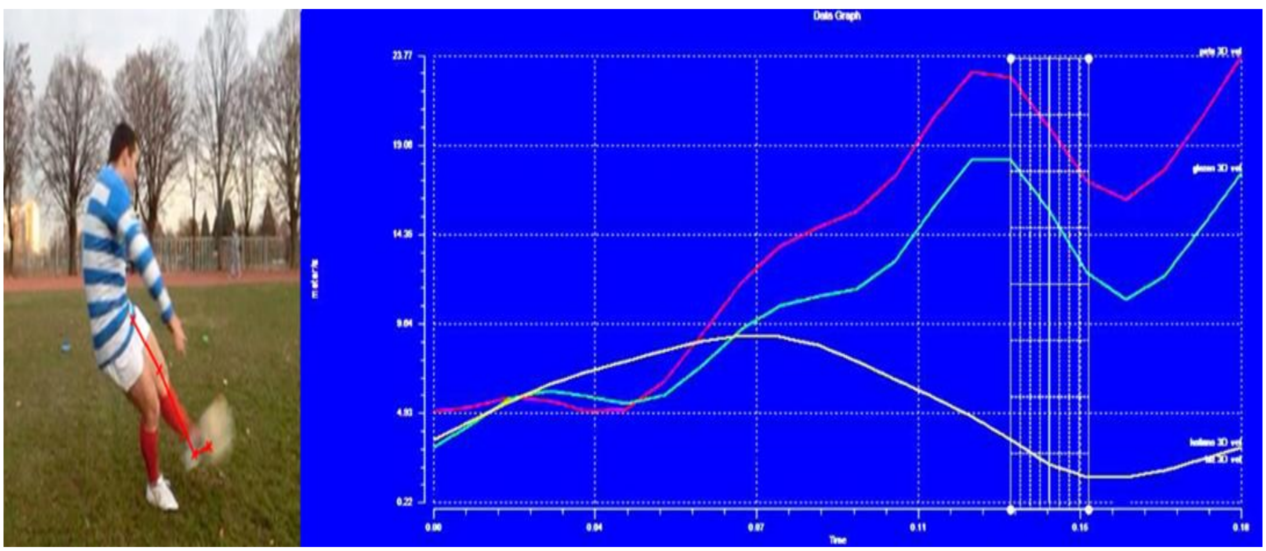

Figure 3.

RESULTS

Table 1 shows that the takeoff angle is within the range 10-90 degrees with an average of 52 degrees. The statistical sample refers to the normal distribution since the coefficient of variation is 30%..

Table 1.

Players	**Degrees**	**Velocity [m/s]**
X	**51,8**	**20,3**
S	**17,8**	**6,3**
V	**30**	**30**
Max	**90**	**35**
Min	**10**	**8**

The striking velocity, according to the laws of body motion of sports biomechanics, is the other key factor causing the ball to take off at an angle to the horizon. The striking velocity range is from **8[m/s] to 35[m/s]**, which is a high value with a 30% variation ration. Our view is that striking the ball should occur when reaching the maximum velocity of the final link included in the kinematic chain.

Obviously, the maximum velocity could be achieved by combining simultaneous increases in heel velocities from the foot, ankle, and knee.

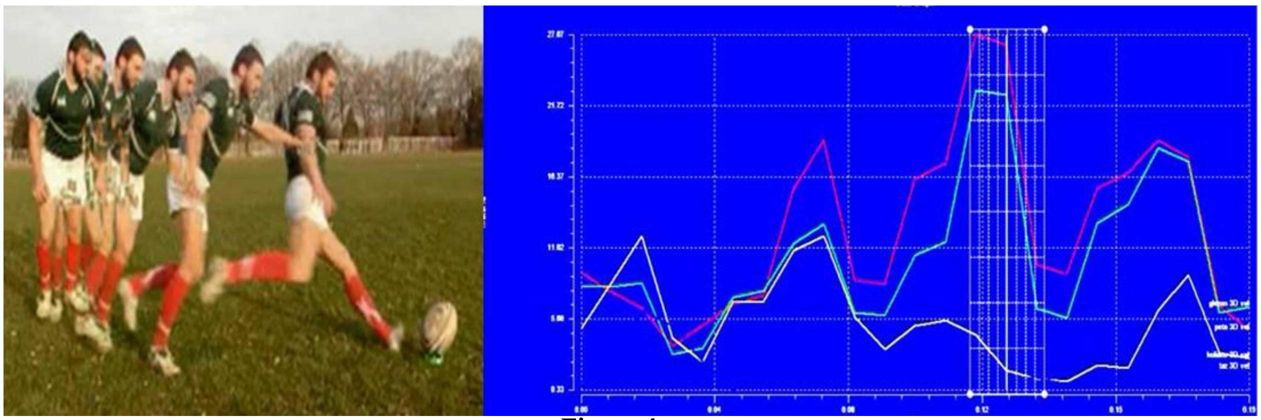

Figure 4.

The frame in **Figure 5** defining the kick shows that the strike is made with the lower foot, ankle and knee velocities are low.

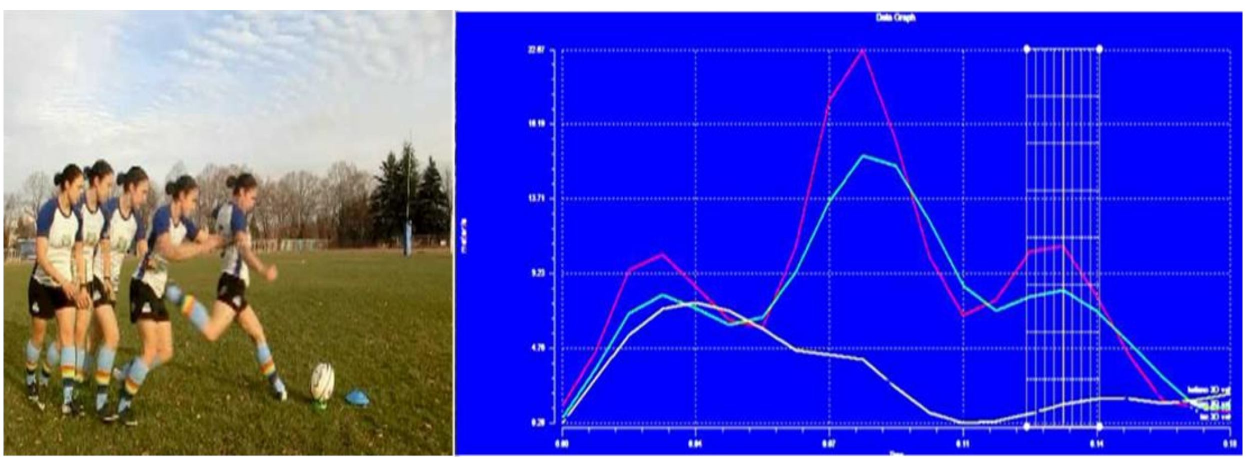

Figure 5.

The proximal-distal pattern of sequential segment motions was observed in all participating players. Before the initial forward swing, the back swing of the hip is monitored. After the backward swing, the hip begins its forward motion and the angular velocity of the hip steadily increases until it reaches its peak at the moment of the final phase of the strike. After reaching its peak, the angular velocity of the hip drops rapidly before it touched the ball. The proximal-distal pattern of sequential movements was observed on all trials, and in most cases the peak forward angular velocity of the lower leg was recorded at, or immediately before, contact with the ball. By contrast, the peak hip velocity was recorded during the forward swing.

Figure 6 shows the effects of each segment (in percentage). As evidenced the greatest effect in kicking goes to the knee (75 ± 8%), followed by hip flexion (13 ± 2%), pelvis velocity (9 ± 1%) and pelvis rotation (2 ± 1%). The contribution of pelvic adduction/adduction and pelvic internal/external rotation is negligible.

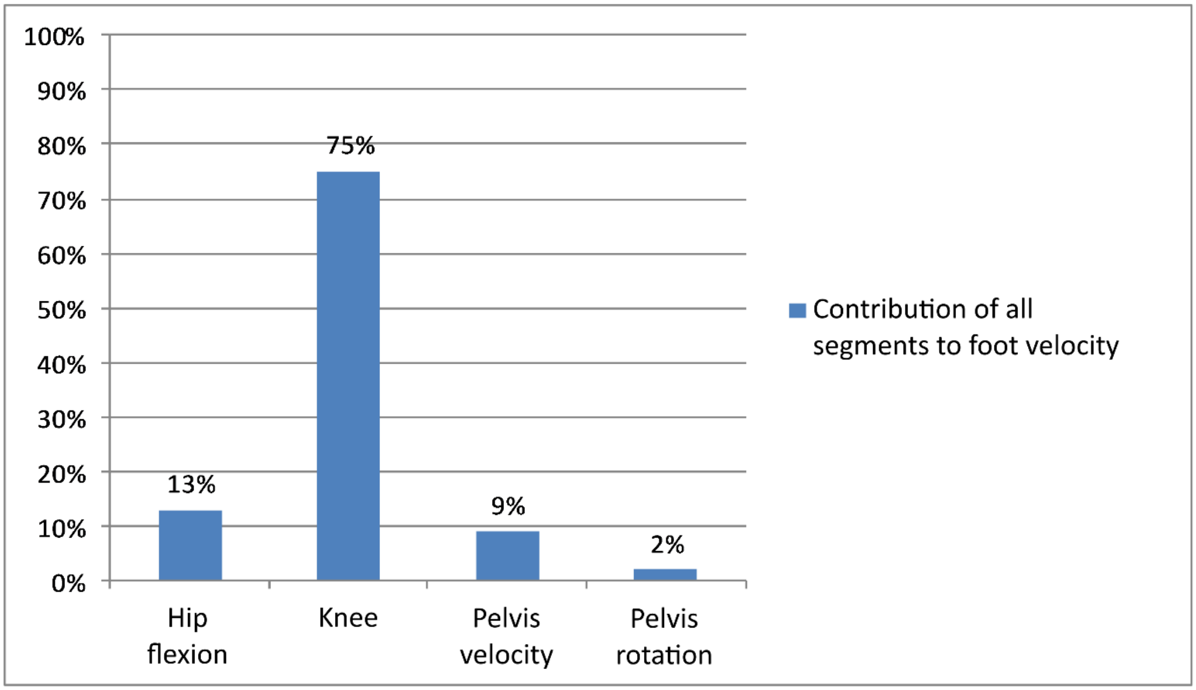

Figure 6.

CONCLUSION

With present study, we determined the contribution of the individual segments to the velocity of foot motion during the strike on the ball. he results showed that knee extension accounted for the largest proportion (75 ± 8%) of the overall strike velocity, followed by hip flexion, velocity and pelvis rotation. The angular velocity parameters indicate a proximal-distal series during the strike, implying that the interaction between adjacent segments plays a significant role during this motion (Putnam, 1993).

A major advantage of the kinematic method used in this study is that the angular and linear velocities of the joints involved in the kinematic chain can be measured using video capture to compute the velocity of the foot and all other components subject to the study. In our future work, we will use this method in comparing different kicking techniques in rugby, i.e. punts, drop kicks, as well as various groups of athletes to assess the effectiveness and speed enhancement of the kick.

The kinematic series of foot strikes in this series is illustrated in several steps. At the last step on the non-kicking foot, the kicking foot swings back: the wider the swing, the higher speed is generated; then, the hip goes forward, followed by the passive motion of the shin and knee; finally, the lower leg (shin) stretches to gain maximum speed, just as the inner part of the foot comes into contact with the ball, at which point the speed of the hip drops. A major contributor to knee extension is the quadriceps *(quadriceps femoris)*, which generates impulses of high-intensity. Therefore, from a biomechanics perspective, strength exercises for the muscle groups around the knee may be of primary importance for rugby players, not only to enhance performance but also to prevent injury during kicking.

REFERENCES

1. Tishinov, O., Velkov, P., Specific motions at kicking in seven-a-side rugby; Scientific Project, National Sports Academy, 2015;
2. 2.Aitcheson, I., and Lees, A., A biomechanical analysis of place kicking in rugby union football. *Journal of Sports Sciences.* 1983, 1: 136–137.;
3. 3.Barfield, W.R., Kirkendall, D.T. and Yu, B., Kinematic instep kicking differences between elite female and male soccer players. *Journal of Sports Science and Medicine.* 2002, 11: 72-79.,

4. 4.Bezodis, N., Trewartha, G., Wilson, C. and Irwin, G., Contributions of the non-kicking-side arm to rugby placekicking technique. *Sports Biomechanics*. 2007, 6(2): 171-186.;
5. 5.Dillman, C.J., Fleisig, G.S., Andrews, J.R., Biomechanics of pitching with emphasis upon shoulder kinematics. *Journal of Orthopaedic & Sports Physical Therapy*. 1993, 18: 402-408.;
6. 6.Grood, E.S. and Suntay, W.J., A joint coordinate system for the clinical description of three-dimensional motions: Application to the knee. *Journal of Biomechanical Engineering*. 1983, 5: 136- 144. ;
7. Isokawa, M. and Lees, A. A biomechanical analysis of the instep kick motion in soccer. In: Science and Football. Ed: Reilly, T., Lees, A., Davids, K. and Murphy, W.J. London, E and FN Spon. 1988, pp. 449-455. ;
8. Lees, A., and Nolan, L., Three-dimensional kinematic analysis of the instep kick under speed and accuracy conditions. In T. Reilly,W. Spinks, and A. Murphy (Eds.), Science and football IV. London: E & FN Spon. 2002, pp. 16-21.;
9. Matsuo, T., Escamilla, R.F., Fleisig, G.S., Barrentine, S.W., Andrews, J.R. Comparison of kinematic and temporal parameters between different pitch velocity groups. *Journal of Applied Biomechanics.* 2001, 17: 1-13.;
10. Nunome, H., Ikegami, Y., Kozakai, R., Apriantono, T., Sano, S., Segmental dynamics of soccer instep kicking with the preferred and non-preferred leg. *Journal of Sports Sciences*. 2006, 24: 529-541.;
11. Putnam, C. A., Sequential Motions of Body Segments in Striking and Throwing Skills - Descriptions and Explanations. *Journal of Biomechanics*. 1993, 26: 125-135. ;
12. Shea, K.M., Lenhoff, M.W., Otis, J.C., and Backus S.I., Validation of a method for location of the hip joint center. *Gait & Posture.* 1997, 5: 157–158. ;
13. Sprigings, E., Marshall, R., Elliott, B. and Jennings, L., A three-dimensional kinematic method for determining the effectiveness of arm segment rotations in producing racquet-head speed. *J Biomech*. 1994, 27(3): 245-54. ;
14. Winter, D.A., Biomechanics and Motor Control of Human Movement (3rd edition). New York: John Wiley & Sons, 2005.;
15. Van den Tillaar, R., Ettema, G., Is there a proximal-to-distal sequence in overarm throwing in team handball? *Journal of Sports Sciences.* 2009, 27: 949-955.