A BIOMECHANICAL ANALYSIS OF THE RUGBY PUNT USING THE PREFERRED AND NON-PREFERRED FOOT

BAUER, TONY
BIOMECHANICS DEPARTMENT LAKEHEAD UNIVERSITY
THUNDER BAY, ONTARIO

The purpose of this study was to investigate and measure the kinematic and electromyographic parameters of the rugby punt when performed for maximum distance using the preferred and non preferred kicking foot. Two dimensional high speed cinematography synchronised with electromyographic recordings of the lower extremity musculature was used for the testing procedure. Film analyses produced kinematic data for six elite subjects performing the rugby punt with both the preferred and non preferred foot. Electromyographic recordings of 3 major lower extremity muscle groups were recorded in synchrony with the kinematic film analysis. Results indicated a lack of coordinated muscle contraction and inferior performances of the non preferred kicking legs of all subjects. Electromyographic records demonstrated a close relationship between changing kinematic variables in lower extremity limb segments and EMG levels during the performance of the rugby punt. Results demonstrated EMG outputs which fluctuated according to the angular acceleration of the lower extremity limb segments during the human ballistic motion of kicking.

REVIEW AND THEORY

Kinematic analyses of the kicking motion have been completed by Plagenhoef (1971). Ball and foot velocities angles of approach and foot and ball surface contact were considered as major determinants of performance. Carlson (1977) demonstrated the effects of increasing the approach distance to the kick and demonstrated significantly higher segmental accelerations and related higher performance levels for the greater approach distances. Smith (1949) compared expert average and novice kickers and measured the affects of the distances the ball was dropped from hands to foot, angle of trajectory and the time period for the completion of the kick. Shorter dropped distances, slightly higher trajectories and lower total time completion periods were characteristic of the expert performers. Macmillan (1975) determined that footpath angle was the major determinant of the launch angle of the ball however considerations were not given to the motion of the ball and the foot and ball contact during impact. The literature indicates limited research in the measurement of kinematic variables when kicking with the preferred and non preferred foot. The recording of muscular sequencing patterns during lower extremity human ballistic movements such as the kick is also limited in the literature. It is hoped that a study of this nature may assist the coach in an understanding of the major controlling variables in kicking with either foot plus provide some insight into the muscular control of human ballistic limb segment motions.

METHODOLOGY

Six elite athletes of national calibre in full training were measured during repeated trials when kicking with both the preferred and non preferred foot. The subject who performed the best with both feet and the subject who recorded the least distance with the non preferred foot were chosen for comparison. Pilot studies established the testing procedures. Subjects were filmed using a 16 mm. Photosonics camera fitted with a 12-120 mm. Angenieux zoom lens. Kicking performances were filmed over a lens to subject distance of 30 metres at 90° to the film plane. Film data reduction was completed using a 16 mm. Triad VR/100 pin registered film analyzer projecting onto a Bendix digitizing board. X and Y co-ordinates for 21 segmental end points were fed into an HP9825A Hewlett Packard Mini Computer through a 9864A Digitizer. The programmed data analysis provided data for:

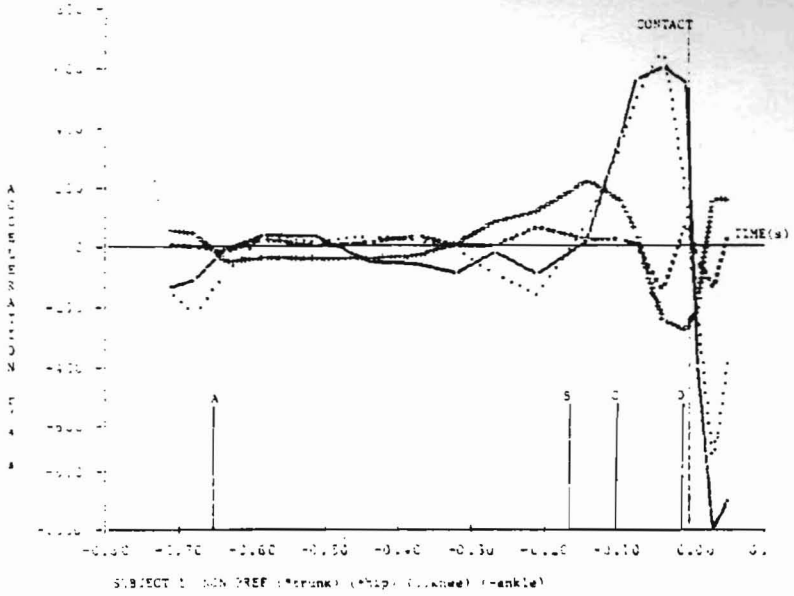
1) Centre of Mass displacement and velocity changes
2) Angular Kinematics including angular velocity and acceleration
3) Linear Kinematics for linear velocity and displacement
4) Joint Angle displacements
5) Electromyography measurement of paper read out recordings of limb segment musculature.

Electromyographical Procedures

The electromyographical analysis used three major muscles in the lower extremity: Rectus Femoris, Biceps Femoris, Tibialis Anterior. Motor points for each muscle belly were located using standard measuring techniques from prominant anatomical points. Bipolar fine wire electrodes were inserted into the muscle belly using a 26 gauge disposable hypodermic needle. Construction and insertion techniques followed guidelines developed by Jonsson (1968). Specialised spring attachments for the fine wires were developed specifically for the study so that subjects experienced limited hinderance during the performance of the kick. Shielded wire electrode leads plugged into a small pre amplifier attached to the subjects' lower back. A 50 foot shielded cable linked the subject to a 4 channel amplifier system which amplified the EMG and stored the signal on a 4 channel F/M (Hewlett Packard 3960) tape recorder. A two channel oscilloscope functioned as an additional visual monitoring system to ensure each EMG channel was functioning correctly. A Photosonics TLG timing system simultaneously pulsed 100 Hz light markings onto the film and one channel of the tape recorder. EMG tape recordings and timing marks were then recorded onto a paper readout oscillograph within a Honeywell Electronic Medical System.

RESULTS

The results presented were based on the kicking performances of six elite subjects. Each subject was filmed over a series of three trials on both the preferred and non preferred foot. The ball displacement of each kick was recorded. Each subject was wired to give electromyographical recordings from the kicking leg. Based on displacement of the ball the best trial for both the preferred and non preferred foot of each subject was chosen for further analysis.



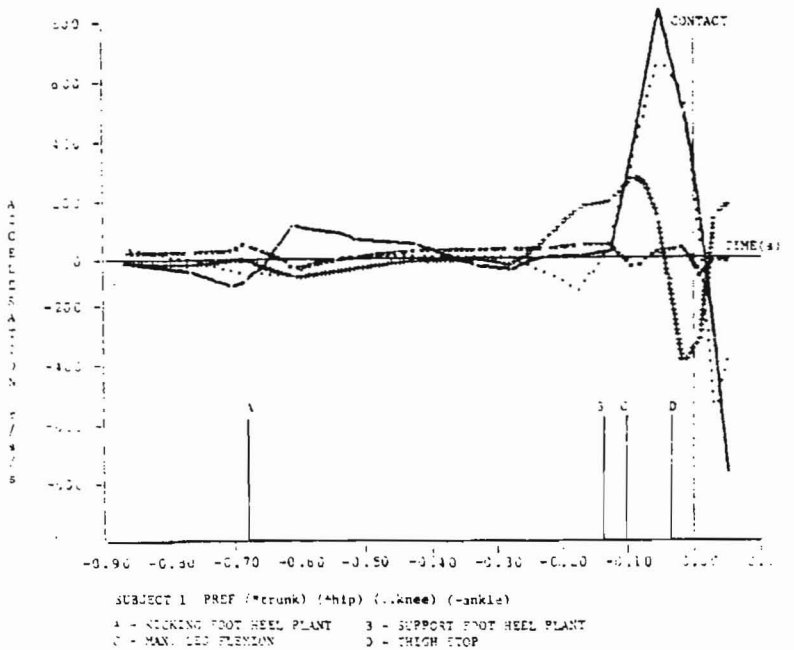


FIG. 1 ANGULAR ACCELERATIONS - SUBJECT 1 NON PREF & PREF FOOT

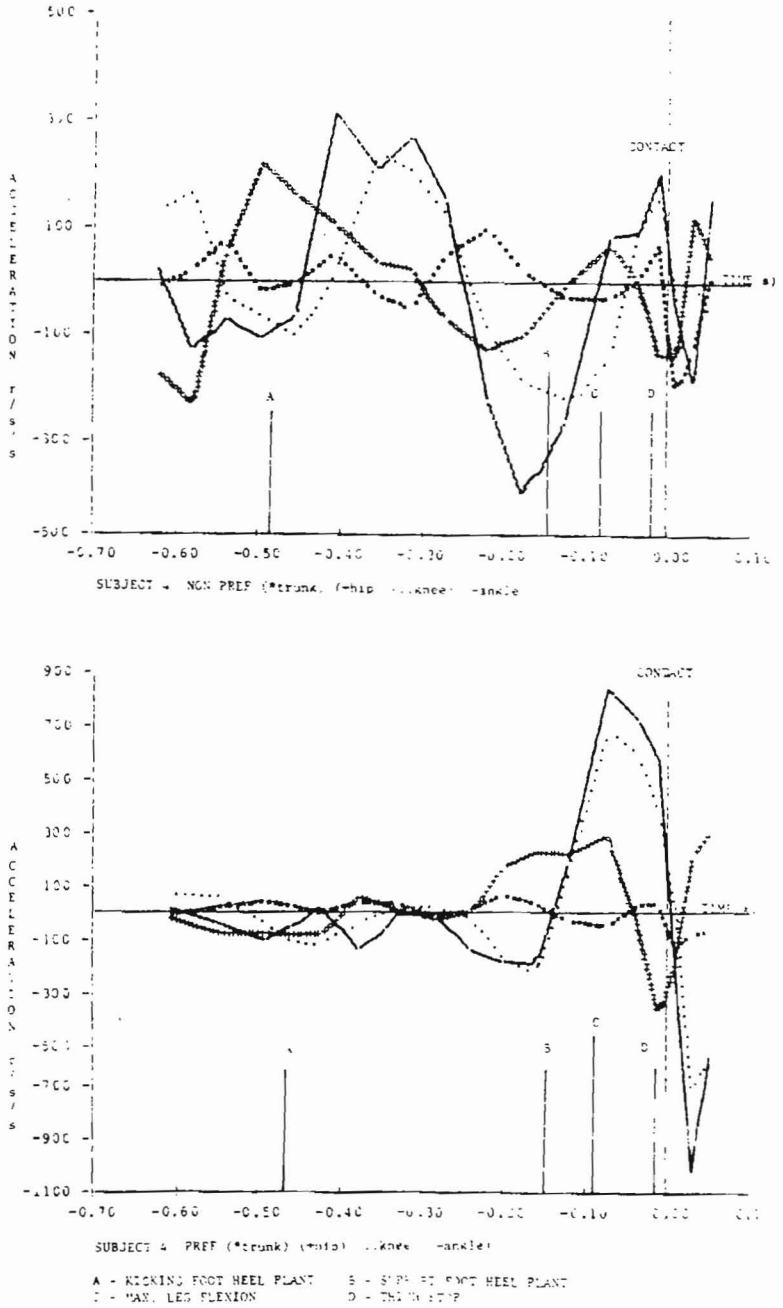


FIG. 2 ANGULAR ACCELERATION - SUBJECT 4 NON PREF & PREF FOOT

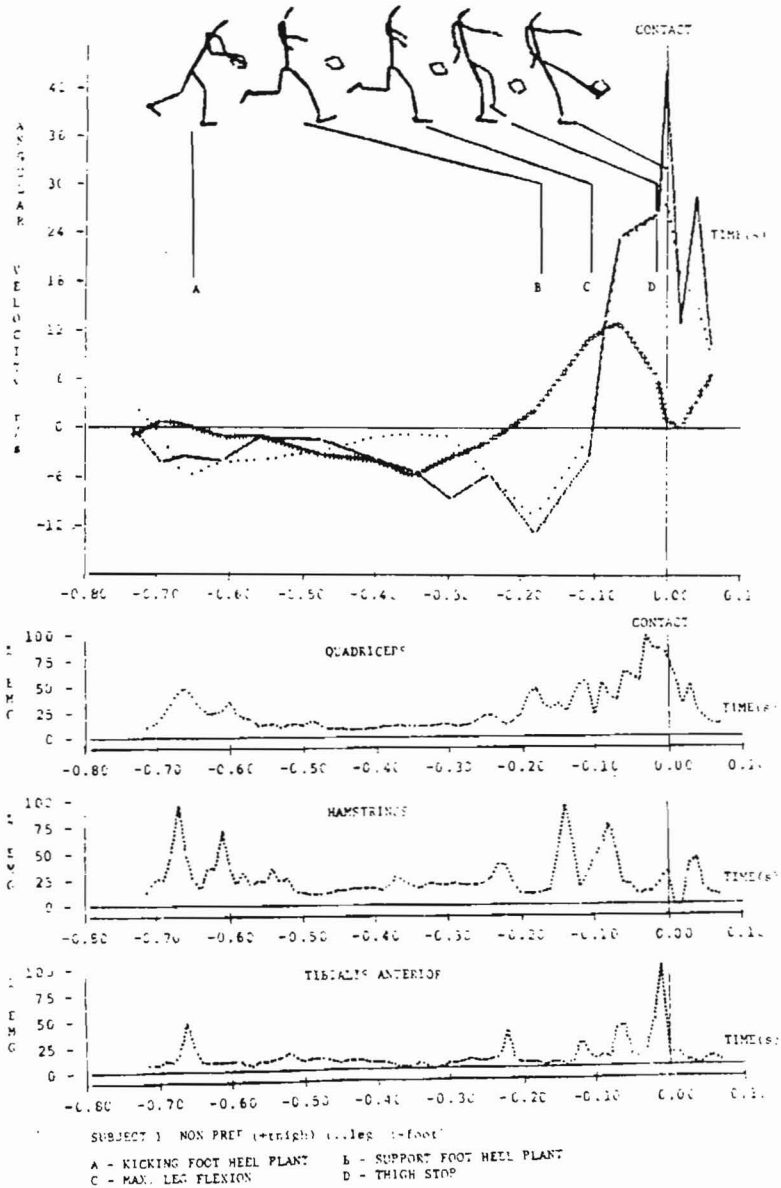


FIG. 3 ANGULAR VELOCITY AND ELECTROMYOGRAPHY - SUBJECT 1 NON PREFERRED FOOT

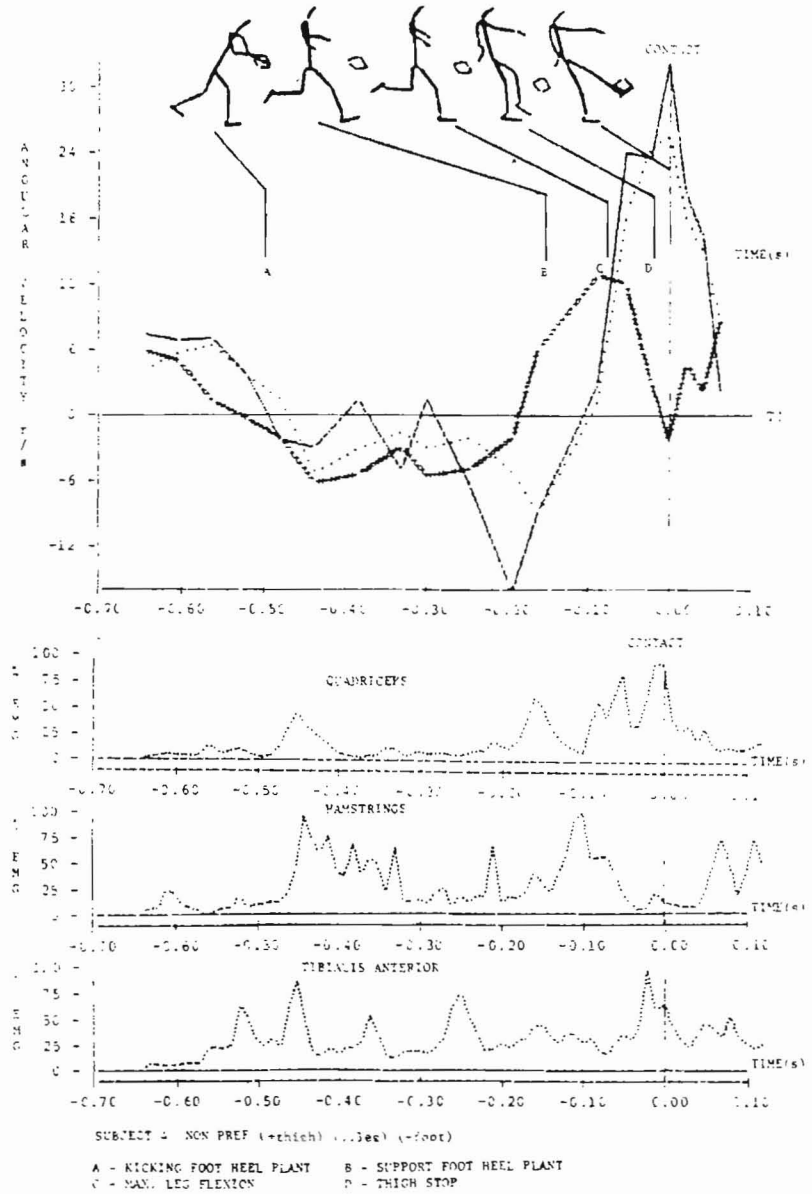


FIG. 4 ANGULAR VELOCITY AND ELECTROMYOGRAPHY - SUBJECT 4 NON PREFERRED FOOT

Angular Accelerations of the trunk, thigh, leg and foot, linear velocities of the trunk, thigh, leg and foot segmental ends, velocities of the centre of mass and angular range of motion of the trunk, hip, knee and ankle were the kinematic parameters presented. Electromyographical data for the Rectus Femoris, Biceps Femoris and Tibialis Anterior muscles is presented with angular velocity variations for the hip, knee and ankle. All the kinematic data is presented in graphical form and is too extensive to be presented here. Examples of angular acceleration differences between Subject 1, the superior performer and Subject 4, the inferior performer are presented in Figs. 1 and 2. Similar variations between the same subjects are demonstrated for EMG recordings and angular velocities in Figs. 3 and 4. The data generally indicates significant differences in the kinematic data between the superior and inferior kicking performances for both the preferred and non preferred foot.

DISCUSSION

Electromyographical data indicated a high percentage of EMG activity in musculature controlling the specific limb segments which were being accelerated. There did not appear to be any difference between superior and inferior performers on preferred and non preferred feet however the levels changed proportionately with the angular acceleration of the particular segment (figs. 2 and 3). Tibialis Anterior EMG levels were the most inconsistent with angular accelerations of the foot, particularly with the superior performer.

In summary results indicated inferior performances for the non preferred foot of all subjects and considerable variation in kinematic data was demonstrated for all subjects, in particular the inferior performer. It is suggested that even greater variations would result if non elite subjects were used. Subject skill levels in this study were considered to be the best available. Electromyographical recordings indicated a close relationship with segmental angular velocities and EMG percentages indicated that there is in fact steady muscular activity during the human ballistic motion of kicking. It was concluded that the inferior performances demonstrated by the inferior kickers and the non preferred foot was a result of the failure of the kicker to effectively maintain the necessary kinematic segmental sequencing processes. Failure to effectively control segmental motion affected momentum transfer through the limb segments and the final momentum transfer to the ball at impact. The kinematic and electromyographic data presented in this study should be extended to unskilled kicking performances to hopefully assist the coach in developing and promoting more effective kicking for not only distance and accuracy but using both preferred and non preferred feet. More in depth study should be developed for an understanding of momentum transfer from the foot to the ball at contact.

REFERENCES

ANGEL, Ronald V. "Myoelectric Patterns Associated with Ballistic Movement." Journal of Human Movement Studies 1:96-103, 1975.

BASMAJIAN, J.V. Muscles Alive. Williams and Wilkins Company, Baltimore, 1974.

BASMAJIAN, J.V. "Electromyographic Analysis." In: Biomechanics: J. Cooper, The Athlete Institute, Chicago, Illinois, 1972.

CARLSON, J., R.W. ALBRIGHT. "A Comparative Analysis of Two Styles of Punt Kicking. Proceedings. Kinesiology: A National Conference on Teaching, June 8-11, 1977.

DEUTSCH, H. A Comparison of Women's Overarm Throwing Patterns; An Electromyographic Analysis. AAHPER, National Convention, Seattle, Washington, 1970.

DILLMAN, C.J. "A Kinetic Analysis of the Recovery Leg During Sprint Running." In: Biomechanics: J. Cooper, Athletic Institute, Chicago, Illinois, 138, 1971.

ELLIOT, B.C. and B.A. BLANKSBY. "Reliability of Averaged Integrated Electromyograms during Running." Journal of Human Movement Studies 2:28-35, 1976.

FISK, C. The Dynamic Function of Selected Muscles of the Forearm: an Electromyographical and Cinematographical Investigation. Ph.D. Thesis, Indiana University, 1976.

HAY, J.G. The Biomechanics of Sports Techniques. Prentice-Hall, Baltimore, 1973.

HOSHIKAWA, T., S. TOYOSHIMA. "Contribution of Body Segments to Ball Velocity during Throwing with Non Preferred Hand." In: R.C. Nelson and C.A. Morehouse (eds.), Biomechanics V-B, 109-116, Baltimore: University Park Press, 1974.

JONSSON, B., and V.E. BAGGE. "Displacement, Deformation and Fracture of Wire Electrodes for Electromyography." Electromyography 8:329-347, 1968.

MACMILLAN, M.B. "The Determinants of the Flight of the Kicked Football." Research Quarterly 46:48-57, 1975.

PLAGENHOEF, S.C. "Methods for Obtaining Kinetic Data to Analyze Human Motions." Res. Quarterly 37:103-112, 1949.

PLAGENHOEF, S. Patterns of Human Motion. Prentice-Hall, Englewood Cliffs, New Jersey, 1971.

ROBERTS, E.M., R.F. ZERNICKE, Y. YOUM, T.C. HUANG. "Kinetic Parameters of Kicking." R.C. Nelson and C.A. Morehouse (eds.). Biomechanics IV: 157-162, Baltimore, University Park Press, 1974.

SMITH, W.H. A Cinematographic Analysis of Football Punting. M.S. Thesis, University of Illinois, 1949.