BIOMECHANICAL FEATURES OF PERFORMANCE DOMINANCE IN THE LOWER LIMBS

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INTRODUCTION: Laterality is almost always observed during the execution of motor skills (McLean & Tumilty, 1993) and involves the functional dominance of one limb or one side of the body over the other. This functional dominance has been observed particularly during the execution of one foot vertical jumps in sports (Fischer, 1988). According to Friberg & Kvist (1988), athletes always use the same leg to perform one foot vertical jumps.

Most of the studies of laterality have simply recorded the dominance of one limb over the other using the performance outcome of the movement as the only criterion (McLean & Tumilty, 1993). However, the reasons for this dominance have not yet been found, and the characteristics which describe the functional differences between the two limbs have not been fully determined (Bragina & Dobrochotowa, 1984).

The study of performance dominance should consider all the stages of the production of the movement, because of the complexity of the motor system. Since the direct study of the neural system is quite difficult, electromyography might be an alternative tool, as it is well established that the characteristics of muscle contraction are the output of the neural function (Basmajian & deLuca, 1985).

The purpose of this investigation was to examine the kinematic, dynamic and myoelectrical characteristics in one foot vertical jumps with the dominant and the non-dominant leg, in order to determine the biomechanical features of the performance dominance in lower limbs.

METHODS: Seventy-nine volunteers (age: 21.3 ± 1.7 years) performed one foot vertical jumps after a preliminary step with the arms akimbo. Each subject performed five vertical jumps with the right leg and five additional jumps with the left leg on a piezoelectric force plate (Kistler), which recorded the ground reaction force with a sampling frequency of 1000 Hz. At the same time the event was recorded by two S-VHS cameras at 60 fields/sec for the three dimensional analysis of the movement. In order to determine the kinematic characteristics of the movement, selected points on the body were digitized using the Ariel Performance Analysis System (APAS). The spatial coordinates of the selected points were calculated using the DLT procedure. For the calibration of the movement space a calibration rectangular cube was used with 23 control points. The raw data were smoothed by a low-pass digital filter, with a cutoff frequency of 6 Hz.

The electrical activity of four muscles of the lower limb was recorded by four active surface electrodes in a bipolar configuration, using the APAS. The electrodes were placed over the bellies of the rectus femoris, the vastus medialis, the long head of biceps femoris and the medial head of gastrocnemius, according to Basmajian & Blumenstein (1983), while the sampling frequency was set at 1000 Hz. The raw myoelectrical data were smoothed by a low-pass digital filter. The analysis of the residuals was used to determine the value of the cutoff frequency at 100 Hz. The

root mean square values (RMS) of the myoelectrical signal were computed and then normalized to the total myoelectrical activity from 100 ms prior to the foot contact until the take off.
The height of the jump was computed from the vertical velocity of the center of mass at the instant of take off, which in turn was calculated from the impulse of the vertical component of the ground reaction force during the stance phase of the jump. The leg that achieved the highest performance of the total ten vertical jumps was defined as the dominant leg.
The correspondence analysis was employed for the evaluation of the data.

RESULTS: During the highest vertical jump with either the dominant or the non-dominant leg, the angular velocity of the hips became positive earlier than the angular velocity of the knees, while the latter became positive prior to the angular velocity of the ankle, as illustrated in Figure 1.

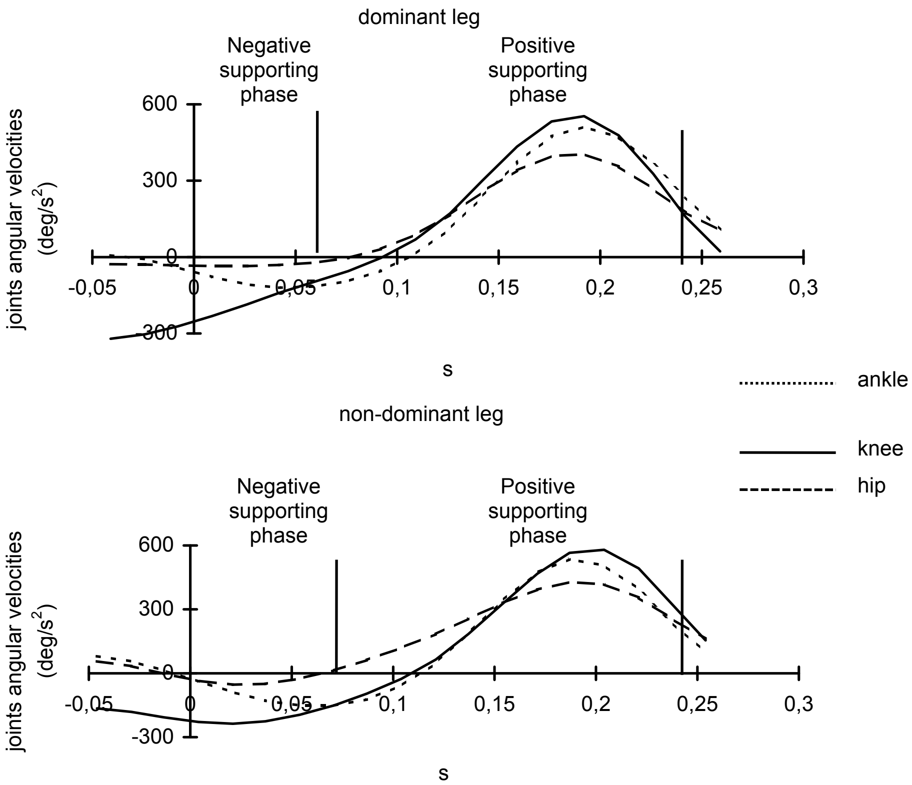

Figure 1. Typical curves of joint angular velocities for the dominant and non-dominant leg.

The correspondence analysis revealed that the second factorial axis, which explained 45.53% of the total variation, was described b< the large differences in performance with the dominant and non-dominant leg and the classes of myoelectrical activity, which are presented in Table 1. No differences between the dominant and the non-dominant legs were observed in the impulse of the ground reaction force.

Table 1. Classes of myoelectrical activity of dominant leg in relation to the non-dominant leg during the phases of the jump

Classes	Coordinates	Contribution	Cosinus
Prior to foot contact			
Biceps femoris greater	-0.33	4.4	0.84
Rectus femoris less	-0.86	7.9	0.81
Vastus medialis less	-0.39	4.8	0.97
Gastrocnemius less	-0.57	3.5	0.31
Negative supporting phase			
Biceps femoris less	-0.24	1.1	1.0
Rectus femoris less	-0.61	4.7	0.93
Vastus medialis greater	-0.31	2.1	0.17
Gastrocnemious greater	-0.88	6.6	0.55
Positive supporting phase			
Biceps femoris less	-0.12	0.8	0.98
Rectus femoris greater	-0.42	2.9	0.53
Gastrocnemious greater	-0.17	1.3	0.44

DISCUSSION: The results revealed that high performance scores were the output of common movement patterns for both the dominant and the non-dominant leg. The backward rotation of the upper body starts earlier than the extension of the thigh, while the latter begins earlier than the extension of the shank. So the body segments contribute in a fixed sequence from proximal to distal to the velocity of the projected body, as in vertical jumps with two legs (Bobbert & van Ingen Schenau, 1988). This movement pattern was the output of a specific pattern of muscle activation. The biceps femoris activated highly before the contact of the foot with the ground, resulted in the backward rotation of the trunk and produced the flexion of the knee as well (Pandy & Zajac, 1991). The same muscle presented less activity during the supporting phase of the jump for both the dominant and non-dominant leg. When the jump was performed with the dominant leg the activity of the biceps femoris before the supporting phase of the jump was greater and during the stance phase was less than when the jump was performed with the non-dominant leg. Since the activity of the biceps femoris of the non-dominant leg during the supporting phase was higher, the muscle acted as a brake during the extension of the knee and did not permit the knee extensors of the non-dominant leg to develop their full power (Bobbert & van Ingen Schenau, 1988). The vastus medialis of the dominant leg presented greater activity during the negative phase of the jump, while the rectus femoris presented greater activity during the positive phase of the jump, which produced a more powerful extension of the knee and increased the height of the jump. This pattern of muscle activation has been found to be responsible for the optimal transition of the mechanical power from the proximal limbs of the body to the distal limbs and finally to the ground (Gregoire et al., 1984).

CONCLUSION: It seems that the improved performance in the vertical jump with the dominant leg was the result of more effective activation of the leg's muscles, which might have been produced because of the more frequent execution of vertical jumps with the dominant leg during daily activities. Thus training may improve the neuromuscular coordination of the non-dominant leg, producing greater numbers of soccer players or jumpers who can perform well with both legs.

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