A BIONIECHANICAL ANALYSIS OF THE SUPPORT PHASE DURING THE PREPARATION AND TAKE-OFF IN LONG AND HIGH JUMPING

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ABSTRACT

The purpose of this study was twofold: a) to describe the support phases during the penultimate and last stride in long and high jumping, in order to define those characteristics which underline a purposeful preparation for the take-off phase, and b) to compare kinematically and determine the technical characteristics which are being demonstrated by top level jumpers in their effort to achieve high performances in long and high jumping, respectively. For this reason, the performances of a long and high jumper, during competition, were recorded by two synchronised video-cameras. A subsequent 3-D analysis was performed by a video-motion analysis (Ariel Performance Analysis System). The motion analysis of the kinematic chain of the upper and lower extremities, with regard to the technique pattern of the take-off phase, shows that, in general, the take-off pattern in both the long and high jump performances look similar. Moreover, it was clearly demonstrated that in the support phase prior to the take-off, a vertical acceleration of the centre of gravity took place during the amortisation, as well as, during the extension of the supported leg.

INTRODUCTION

It is well established that the aim of the take-off technique, in long and high jumping, requires a special preparation phase, in order to be achieved a lowering of the centre of gravity (CG) without a significant loss of running speed.

The purpose of this study was twofold:

a) To describe the supporting phases during the penultimate and last stride (take-off) in long and high jumping in order to find out those characteristics which underline a preparation for the take-off.

b) To compare kinematically and determine the technical characteristics which are being demonstrated by top-level jumpers in their effort to achieve high performances in long and high jumping.

METHODOLOGY

The long jump performance of the athlete "K.K." (8.14m), as well as, the high jump performance of the athlete "L.P." (2.36m) during a competition, were recorded by two synchronised video cameras (30Hz). A subsequent 3-D analysis was performed by a video motion analysis system (Ariel Performance Analysis System).

The sequence of analysis included two strides: the penultimate and the last stride just before the take-off phase in both performances.

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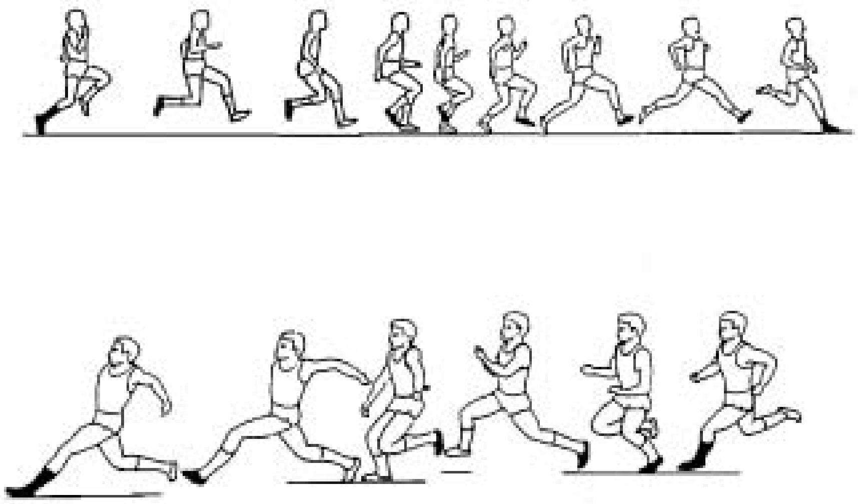

Figure 1 presents the kinesiogram of the last two strides in long and high jumping, respectively.

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RESULTS AND DISCUSSION

PREPARATION PHASE. The length of the penultimate stride of the long jumper ("K.K.") is 2.32m and that of the last stride was 2.08m, whereas the corresponding lengths for high jumper ("L.P.") is 2.35m for the penultimate stride and 2.04m for the last stride, respectively.

The knee angle at the beginning of the penultimate supporting phase for the long jumper is 143 deg. During this supporting phase, a reduction of 23 deg at the knee angle is observed and the long jumper takes-off with a knee angle of 145 deg. At the beginning of the last support of the preparation phase, the long jumper has a knee angle of 145 deg. and during the support, reduces to 15 deg. The long jumper takes-off from the contact phase with a knee angle of 147 deg.

The angular differentiation of the knee joint produced -0.02m of vertical variation of the CG during the penultimate contact phase, and -0.03m during the last support. The high jump athlete at the start of penultimate contact, during the preparation phase, has 145 deg at the knee joint. During the support, the angle decreases about 6 deg and the athlete takes-off from the support phase with an angle of 140 deg. At the beginning of the last contact, the angle of the knee joint is 139 deg. During the particular contact phase, the above mentioned angle decreases 9 deg and the athlete takes-off from this position with knee joint angle of 135 deg.

The vertical displacement of CG during the high jump results in a different motor behaviour. At the penultimate contact, the athlete increases the vertical height of CG 0.02m (from 0.95m to 0.97m). At the last contact, the high jumper decreases the vertical height of CG -0.04m (from 0.94m to 0.90m).

The results indicate that the preparation phase for the take-off by both athletes is being performed by lowering the vertical height of their CG during the penultimate stride (0.03m for the long jumper and 0.04m for the high jumper, respectively). It was found that the technique pattern of the kinematic chain of the lower extremities is executed similarly by both athletes during the last support of the preparation phase.

The relatively high values of the knee joint flexion (120 deg and 130 deg for the long and high jump, respectively) and the relatively low values of the vertical change of CG (0.03m and 0.04m for the long and high jump, respectively) might be explained by observing the position of the limb (foot, shank, thigh) in the kinematic chain.

The shank and the thigh are moving from a vertical position to the horizontal (knee flexion), while, simultaneously, the foot is moving in opposition. This counterbalancing movement determines the values of the change of the CG's height.

Summarising the motor behaviour of the two jumpers, with regard to the length of their stride, the angular variability of the knee joint and the vertical displacement of the CG during the preparation phase:

a) The stride length of the last two strides is similar to both athletes probably due to the development of the vertical displacement of the C.G.

b) The differentiation of the knee joint angle and the corresponding vertical displacement of the CG, could be the result of the particular movements of the remaining body limbs, especially from the upper body, the hands, the foot and the swinging leg.

c) For the long jump, the vertical displacement of the CG begins from the penultimate support (-0.02m) and maximises at the last support (-0.03m). For the high jump, the vertical displacement of the CG exist only during the last support (-0.04m). The large differences between the horizontal velocity of the athletes' CG (10.22m/sec for the long jumper and 6.88m/sec for the high jumper) and the variation of their motor behaviour patterns (i.e., for the long jumper the main horizontal displacement of the CG and for the high jumper the main vertical displacement of the CG), are the main factors for the differences in their motor performances.

TAKE-OFF. For the long jumper, the angle of the knee joint at the starting point of the support phase was 161 deg. During the support phase the angle decreased 11 deg. During the take-off the angle of the knee joint was 168 deg. The vertical displacement of the CG at the support phase was 0.26m.

For the high jumper, the angle of the knee joint at the starting point of the support phase was 168 deg. The angle of the knee joint decreased 8 deg during the support phase. During the take-off the angle was 175 deg. The vertical displacement of the CG was 0.33m.

At the propulsion phase one can see:

a) The long jumper, to a greater extent than the high jumper, uses the variation of the angle of the knee joint to develop vertical variations in the CG. This is related mainly to a number of factors concerned with the performance variables, horizontal velocity of the CG and preparation of the motor system for the jump performance.

b) The vertical displacement of the CG suggests the differences in motor behaviour between the two jumpers during the propulsive phase of the jump. The long jumper having high horizontal velocity (which is necessary for the long jump performance), prefers to use the knee more than other limbs in the kinematic chain, and produce differences in the vertical axis.

c) The high jumper runs with significantly lower horizontal velocity. In addition he uses the horizontal velocity for a maximum vertical velocity at the point of the take-off (4.65m/sec). Having a lower speed he is able to use more limbs (hands, swinging leg, upper body, and foot), for development of a maximum vertical velocity of the CG.

d) The long jumper with a greater variation at the knee joint, failed to produce the vertical displacement of the high jumper but preserved levels of horizontal velocity.

Motion analysis of the kinematic chain of lower extremities, with regard to the technique pattern of the take-off, shows that the take-off pattern is similar in both the long and high jump performances. It is important to note that, during the support phase of the take-off a vertical acceleration of the CG was found to take place during the amortisation, as well as, the extension of the take-off leg.

CONCLUSIONS

The variations of the CG during the preparation phase appears to be important for the final result. High performances in long jumping are possible for jumpers who run with high speed towards the take-off board and use optimal technique and strength. High performances in high jumping are possible by jumpers who use optimal technique and strength to achieve high vertical variations in the velocity of the CG.

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