Journal of Biomechanics 44 (2011) 2207–2212

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
www.JBiomech.com

The effects of initial conditions and takeoff technique on running jumps for height and distance

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ARTICLE INFO

Article history:
Accepted 15 June 2011

Keywords:
Running jumps
Initial conditions
Takeoff technique

ABSTRACT

This study used a subject-specific model with eight segments driven by joint torques for forward dynamics simulation to investigate the effects of initial conditions and takeoff technique on the performance of running jumps for height and distance. The torque activation profiles were varied in order to obtain matching simulations for two jumping performances (one for height and one for distance) by an elite male high jumper, resulting in a simulated peak height of 1.98 m and a simulated horizontal distance of 4.38 m. The peak height reached/horizontal distance travelled by the mass centre for the same corresponding initial conditions were then maximised by varying the activation timings resulting in a peak height of 2.09 m and a horizontal distance of 4.67 m. In a further two optimizations the initial conditions were interchanged giving a peak height of 1.82 m and a horizontal distance of 4.04 m. The four optimised simulations show that even with similar approach speeds the initial conditions at touchdown have a substantial effect on the resulting performance. Whilst the takeoff phase is clearly important, unless the approach phase and the subsequent touchdown conditions are close to optimal then a jumper will be unable to compensate for touchdown condition shortcomings during the short takeoff phase to achieve a performance close to optimum.

1. Introduction

Running jumps are an integral part of many activities and can be generally considered to consist of three main phases: the approach, the takeoff and the flight phase (Greig and Yeadon, 2000). The takeoff is considered to be the most important of the three phases while the approach phase is vital for its preparation (Dapena, 1988). The main purpose of the approach phase is therefore to place the athlete in the optimum initial conditions for the takeoff phase. Due to the specific requirements of high jumping and long jumping there are differences in athletes' optimal initial conditions. The optimal approach speed for long jumping is faster than for high jumping where an 'intermediate' approach speed is optimal (Greig and Yeadon, 2000; Alexander, 1990). Using a theoretical model, Alexander (1990) found that long jumping has a steeper optimum plant angle (the angle between the backward horizontal and the line joining the ankle and hip of the takeoff leg) than in high jumping where the optimum plant angle is closer to the horizontal. The shallower plant angle utilised by high jumpers facilitates the production of vertical velocity. The steeper plant angle utilised in long jumping allows the athlete to gain vertical velocity whilst maintaining a fast horizontal velocity (Hay, 1981). Theoretically a straight plant leg is optimal for both high jumping (Grieg and Yeadon, 2000) and long jumping (Seyfarth et al., 2000) and a greater backward lean of the trunk at touchdown is needed for high jumping (Dapena, 1988), while in long jumping the trunk angle is closer to vertical (Graham-Smith and Lees, 2005).

Differences primarily in initial conditions at touchdown lead to a shorter takeoff phase of around 120 ms for long jumping (Seyfarth et al., 2000; Bridgett and Linthorne, 2006) compared to a longer contact time of around 180 ms for high jumping (Aura and Viitasalo, 1989). During the takeoff phase high jumpers try to maximise gain in vertical velocity (Greig and Yeadon, 2000) while long jumpers attempt to develop vertical velocity whilst limiting the inevitable loss in horizontal velocity (van Don and Hay, 1994). The amount of knee flexion of the takeoff leg during the final contact phase has been identified as one of the factors that influence the production of vertical velocity (Dapena, 1980). In the high jump the knee joint flexes to an angle in the region of 133° (Dapena, 1980) whereas in the long jump the knee flexes to approximately 140° (Graham-Smith and Lees, 2005), although the effect of different approach speeds on knee kinematics in each type of jump is not clear.

It is clear that both the approach phase (initial conditions at touchdown) and the takeoff phase are critical for a successful

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doi:10.1016/j.jbiomech.2011.06.010