BIOMECHANICAL ANALYSIS OF TWO LONG JUMP TAKE-OFF TECHNIQUES

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A technique intervention strategy was used whereby the run-up velocities of two long jumpers were systematically varied. The take-off parameters that define the athlete's take-off technique showed reproducible changes in response to changes in run-up speed. The two athletes in the study used slightly different take-off techniques to achieve their performances.

KEY WORDS: athletics, long jump, take-off technique, intervention study, run-up velocity

INTRODUCTION: The long jump take-off requires a rapid change of direction. During ground contact, the athlete must plant his take-off leg at an appropriate angle to the horizontal and with an appropriate amount of knee bend. The athlete must also execute a movement that produces the optimum combination of take-off angle and take-off velocity for the flight phase of the jump. This is often best achieved by a reduction in horizontal velocity at the expense of a gain in vertical velocity. Athletes can approach this by focusing on minimizing the loss in horizontal velocity or on generating maximal vertical velocity. Few have explored the idea that both strategies can produce equally successful performances (Vorobiev et al., 1992).
While the strong positive relation between the horizontal velocity at touchdown and jump distance is well established (hay, 1985; lees *et al*, 1993), few studies have used an intervention approach to explore the relation between the horizontal velocity at touchdown and other take-off parameters. Of those whom have explored the long jump take-off, (hay, 1993; nixdorf and bruggemann, 1990; lees *et al*, 1994) few have investigated the techniques used by the individual senior and junior athlete.
The present study used an intervention approach to deliberately change the run-up velocity of a senior and a junior athlete. The resulting changes between horizontal touchdown velocity and take-off parameters were noted, and the different technical strategies used by the two athletes were explored.

METHODS: A senior male long jumper (age 27 years; weight 80 kg; height 1.88 m) with a personal best performance of 8.30 m and a junior male long jumper (age 17 years; weight 62kg; height 1.75 m) with a personal best performance of 7.58 m were recruited for the study. Data was collected over 5 competition and 8 training sessions for the senior athlete and 3 competition and 2 training sessions for the junior athlete. This summated to a total of 118 jumps for the senior athlete and 59 jumps for the junior athlete which included jumps for maximum distance using their normal competition run-up lengths, and jumps using shorter and slower run-ups. This generated varying run-up velocities which ranged from 4.8–11.0m/s and 4.9–9.6 m/s for the senior and junior athletes, respectively. The jumps were recorded in the sagittal plane with a high-speed video camera operating at 100 Hz. Image sequences were digitised manually and an Ariel Performance Analysis System was used to obtain run-up and take-off data. Pearson's Product Moment Correlation Coefficient Technique was used to explore the relation between run-up velocity and other take-off variables for the two athletes.

RESULTS AND DISCUSSION: As expected, both athletes showed a very strong positive relation between run-up velocity and jump distance (Figure 1). The athletes jumped similar distances at corresponding run-up speeds, but the senior athlete had a faster maximum run-up velocity and so achieved a greater maximum jump distance. The coefficient of determination for the jump distance versus run-up velocity data was $r^2 = 0.92$ for the senior athlete and $r^2 = 0.98$ for the junior athlete. That is, variations in run-up velocity accounted for 92% and 98% of the observed variation in jump distance.

The take-off action always resulted in a reduction in horizontal velocity, and both athletes generated a roughly constant vertical take-off velocity across all run-up velocities. However, the junior athlete tended to use a slightly greater average vertical take-off velocity (3.8 m/s) than the senior athlete (3.4 m/s). Even though the jumpers generated vertical velocity during the take-off, they were still able to transfer most of their run-up velocity through to horizontal take-off velocity and so their resultant take-off velocity steadily increased with increasing run-up velocity (Figure 2).
For both athletes the take-off angle steadily decreased with increasing run-up velocity (Figure 3). Changes in take-off angle were mostly determined by changes in horizontal take-off velocity because the athlete's vertical take-off velocity remained almost constant. For the jumps at the athlete's competition run-up velocity, the senior athlete used a lower take-off angle (mean = 21.4°, s = 1.6°) than the junior athlete (mean = 23.5°, s = 1.0°).

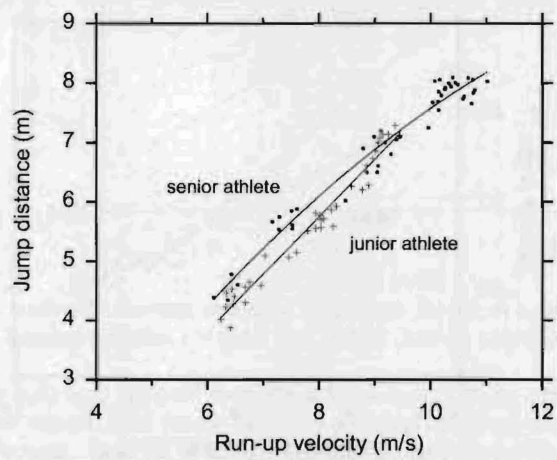

Figure 1 Relations between run-up velocity and jump distance for two long jumpers. (Senior athlete •, Junior athlete +).

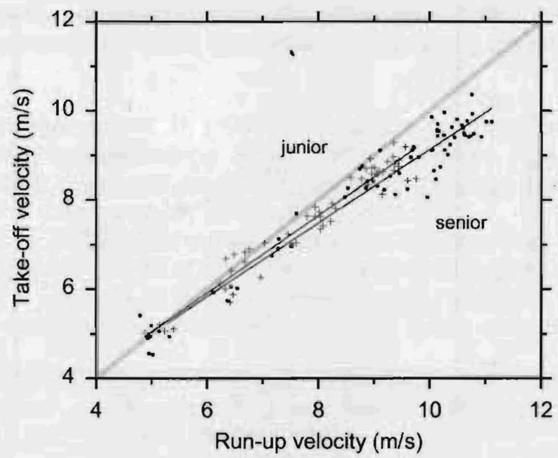

Figure 2 Relations between run-up velocity and take-off velocity for two long jumpers. Also shown is the line of 100% transfer of run-up velocity to take-off velocity (grey line). Senior athlete: r = 0.55 (p < 0.01). Junior athlete: r = 0.97 (p < 0.01).

The athletes suffered a net loss of mechanical energy during the take-off, and this loss steadily increased with increasing run-up velocity (Figure 4). Therefore, the senior athlete lost more energy due to his faster speeds at touchdown. The observed changes in mechanical energy were mostly a reflection of the changes in kinetic energy (i.e. velocity), rather than changes in gravitational potential energy (i.e. height).
The observed differences in vertical take-off velocity, resultant take-off velocity, take-off angle, and take-off energy between the two athletes are reflections of their different technical approaches to the take-off. The senior athlete concentrated more on minimising the loss in horizontal velocity by using a lower take-off angle, whereas the junior athlete concentrated more on generating a high vertical take-off velocity and accepting the resulting greater loss in take-off energy. Similar strategies towards achieving a successful long jump performance were reported by Vorobiev et al. (1992) in a study of Mike Powell and Carl Lewis at the 1991 World Championships in Athletics.

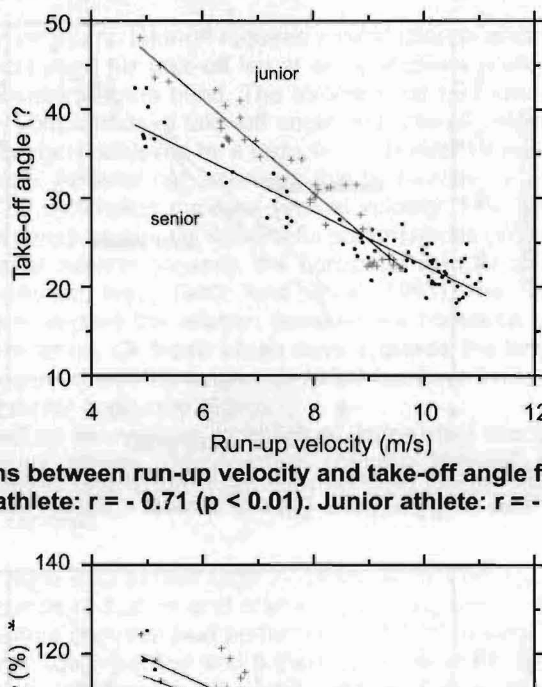

Figure 3 Relations between run-up velocity and take-off angle for two long jumpers. Senior athlete: r = - 0.71 ($p < 0.01$). Junior athlete: r = - 0.93 ($p < 0.01$).

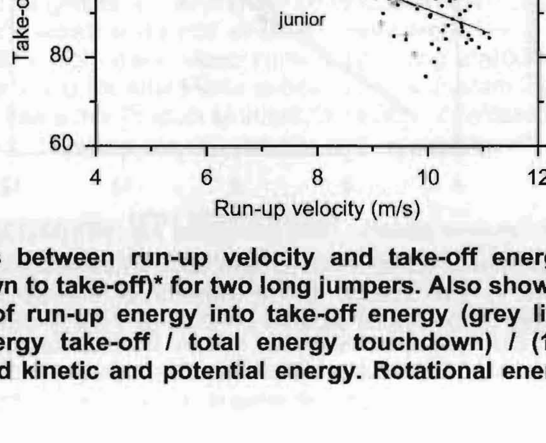

Figure 4 Relations between run-up velocity and take-off energy (% change from touchdown to take-off)* for two long jumpers. Also shown is the line of 100% transfer of run-up energy into take-off energy (grey line). * Calculated as (total energy take-off / total energy touchdown) / (100/1). Total energy comprised kinetic and potential energy. Rotational energy was assumed to be zero.

The athletes used a leg angle at touchdown of just over 60°, and this angle decreased only slightly with increasing run-up velocity. Both athletes steadily increased their knee angle at touchdown with increasing run-up velocity (Figure 5). A straighter knee may be required at high run-up velocities to prevent excessive flexion of the knee during the take-off. When jumping using their competition run-up velocity, the athletes preferred to use a knee angle of about 165°.

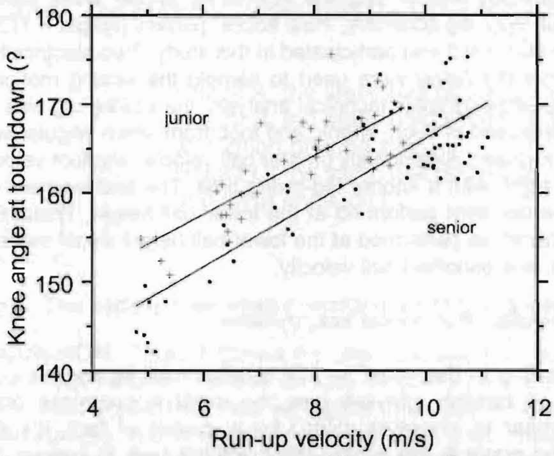

Figure 5 Relations between run-up velocity and knee angle at touchdown for two long jumpers. Senior athlete: $r = 0.66$ ($p < 0.01$). Junior athlete: $r = 0.81$ ($p < 0.01$).

CONCLUSION: The optimum take-off technique for a long jumper changes with increasing run-up speed. As the athlete runs faster he uses a straighter knee angle at touchdown, the take-off angle decreases, take-off velocity increases, and the leg angle at touchdown remains almost unchanged. The two athletes used different approaches to the long jump take-off. The senior athlete had a higher horizontal velocity at touchdown and a higher resultant take-off velocity, but a lower vertical take-off velocity, a smaller take-off angle and a greater loss in energy than the junior athlete. Maximising the vertical take-off velocity may be as successful as minimising the loss in horizontal velocity during the take-off.

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