VISUAL REGULATION DURING COMPETITION LONG JUMPS AND RUN-THROUGHS

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Previous investigators have reported that the ability of long jumpers to visually regulate their stride pattern as they approach the take-off board is critical for success. The importance of visual regulation (VR) on long jump (LJ) distance was assessed in six national-class competitors during two simulated competitions. Linear regression analyses indicated that increased VR contributes to a high average approach velocity - a key predictor of LJ distance. Early VR enabled the athletes to make small systematic adjustments to stride length in order to strike the board in an optimal take-off position, without sacrificing approach velocity. Athletes practice their LJ approach by repeating the stride pattern of the approach, but without the take-off. The current study established that these 'run-throughs' (RT) don't accurately simulate the VR characteristics of a LJ approach. One strategy to increase the VR required during RT's may be to place additional targets across the runway for the athletes to negotiate whilst approaching the take-off board, without compromising approach velocity.

KEY WORDS: long jump, targeting, training, perception.

INTRODUCTION: A long jumpers' run-up has two objectives, to develop a high approach velocity and to strike the take-off board in an optimal take-off position. Accordingly, previous researchers have identified two distinct phases during athletes' run-ups in long jump (LJ) competitions. Lee et al. (1982) reported that long jumpers use a well-practiced stride pattern to accelerate up to optimal speed, thereafter; they visually regulate their strides to ensure precise foot placement on the take-off board. The length of the visual regulation (VR) phase varies between athletes (Galloway & Connor, 1999); however, Hay (1988) reported that national-class long jumpers made 67% of their total step adjustments in the final two strides before take-off. Lee et al. (1982) proposed that athletes who only visually regulate immediately prior to the take-off board may have to significantly alter their stride pattern in order to record a legal jump. Such large modifications may severely compromise take-off velocity and therefore, jump distance. A relationship between VR and LJ distance has not been quantified by previous research. Research into gymnastic vault performance has, however, reported significant positive correlations between VR and flight time (Bradshaw & Sparrow, 2001). Therefore, it is reasonable to suggest that early VR will contribute to increased LJ flight time and hence, distance. The relationship between VR and LJ distance was examined by the current study.

The athlete's objective during the VR phase is to adjust his or her stride pattern in relation to the take-off board to correct for the small errors in foot placement that accumulate during the acceleration phase (Lee et al., 1982). Athletes and coaches attempt to minimize these errors by repeatedly practicing the LJ run-up. Further run-up practice is gained by performing run-throughs (RT), which involves the full approach, foot plant, but without the take-off. Without the physical stress of take-off, athletes can perform a high number of RTs with minimal risk of injury. The validity of using RT to simulate LJ approaches has, however, been questioned. Lee et al. (1982) reported that the VR of a RT was approximately half that of a competitive LJ. Whether this difference was statistically significant, or can be generalised beyond the three athletes observed by Lee et al. (1982) was not, however, reported. Statistical analysis notwithstanding, these authors declared that removing the take-off simplified the perceptual demands of the task, and hence, reduced the need for early VR. This potentially important difference between RT and LJ run-ups has not, however, been subsequently addressed in scientific literature or coaching practice. The second aim of the current study was, therefore, to assess the validity of simulating LJ run-ups with RTs.

METHOD: Three male (height: 1.78m ±0.05, weight: 69.60kg ±5.81, PB: 7.38m +0.14) and three female (height: 1.75m ±0.03, weight: 65.03kg ±6.05, PB: 6.22m +0.06) national-class long jumpers participated in two simulated competitions held at the start (January) and end (April) of the domestic competitive season. The January and April sessions were performed in 2.0m/s tailwinds and headwinds, respectively. The athletes completed three RTs, six competition LJs, followed by three RTs. The two experimental competitions were conducted in accordance with Athletics Victoria regulations.

LJ run-ups and RT's were filmed using a panning 50Hz digital camera (Sony DVCam) positioned adjacent to the runway, and elevated to 6m using a scissor lift platform. Two marker strips, placed either side of the approach runway, with alternating 50cm black and white intervals were used as a scale-reference for the subsequent analysis of video footage. Video footage collected from this camera was captured (Canopus) onto a computer as an AVI file. Frame-by-frame analysis of captured video footage identified each foot placement during LJ run-ups and RT. The x,y co-ordinates of each footfall at toe-off were inputted into an Excel program to scale the measurements and calculate the length, duration, frequency, and velocity of each step. The standard deviation of footfall positions across the 6 LJ and 6 RT trials was used to identify the onset of visual control. The peak standard deviation of footfall position signalled the end of the acceleration phase and the emergence of global VR where the athlete begins to adjust their steps for the position of the board. The target perception threshold was utilized to determine the onset of local VR (Bradshaw & Sparrow, 2002), where the athlete can perceive the spatial characteristics of the target and adjust their steps to strike the board for take-off. Mean step data for the acceleration, global and local VR phases, and the entire approach were also calculated.

Two cameras operating at 250Hz (Redlake Motionscope PCI500) were placed adjacent to the take-off board, at oblique angles, to film each LJ take-off three-dimensionally. A 2.5-m calibration rod (2.5cm2), fitted with a spirit level was filmed at eight locations to act as a scale reference for subsequent analyses. The athletes' velocity, trunk and leg angle at touch-down and take-off were analysed two-dimensionally (Video Expert II). The total ground contact time during the take-off was measured from the high-speed video footage.

A linear regression analysis was used to quantify the relationship between selected approach and take-off variables and LJ distance. The predictive strengths of each variable were ranked according to the product of the standardised regression coefficients ( ), and the standard deviation for each variable. A one-way analysis of variance with repeated measures of task (LJ, RT) and month (January, April) was used to isolate differences between the gait characteristics of RT and LJ approaches. Statistical significance was set at $P < 0.05$ for all analyses. All statistical procedures were performed using Microsoft Excel 2000 and SPSS 11.0 for Windows.

RESULTS AND DISCUSSION: The findings presented in Table 1 confirm the importance of a high approach velocity for successful LJ performance. Specifically, predictive modeling of LJ distance revealed that an increase in average step velocity of 0.1m/s would increase LJ distance by 9cm. A high approach velocity is generated through the acceleration phase of the run-up. The importance of acceleration phase velocity on LJ distance has also been verified by the current study (Table 1). Lee et al. (1982) insisted that the maintenance of a high velocity whilst sprinting toward a narrow target demands an early VR, such that the small adjustments to step length required to negotiate the take-off board can be made over a relatively long period. Late VR can lead to drastic changes to stride pattern and large reductions in approach velocity. The significance of VR distance on the maintenance of step length and velocity during the VR phase and on jump distance is also demonstrated in Table 1, substantiating Lee et al.'s (1982) assertion.

The athlete's position at take-off is also a key predictor of LJ distance (Table 1). Specifically, a decrease of 1o in touch-down leg angle can increase jump distance by 13cm. A decreased leg angle at touch-down indicates a relatively long last stride, which if preceded by a drop in the athlete's centre of gravity during the penultimate stride, promotes a more vertical take-off (Ramlow & Romanautsky, 1997). Considerable concentration is required for the physically demanding task of altering the stride pattern to strike the board, whilst simultaneously preparing for the take-off.

Table 1 The best predictors of LJ performance. All linear models are statistically significant (P < 0.01). The beta ( ) value indicates the change in LJ length (m) with an increase of one unit in the predictor

Rank	Predictor	β	β x SD
1	Average Step Velocity (m/s)	0.888	0.384
2	Touch-Down Leg Angle (^{0})	-0.125	-0.299
3	Acceleration Phase Velocity (m/s)	0.481	0.219
4	Acceleration Phase Step Velocity (m/s)	0.496	0.198
5	Visual Control Phase Step Velocity (m/s)	0.169	0.126
6	Take-Off Resultant Hip Velocity (m/s)	0.110	0.117
7	Touch-Down Resultant Hip Velocity (m/s)	0.101	0.108
8	Visual Control Phase Velocity (m/s)	0.097	0.092
9	Take-Off Trunk Angle (^{0})	0.012	0.090
10	Visual Control Step Length (m)	0.470	0.088
11	Acceleration Phase Step Length (m)	0.579	0.066
12	Visual Control Distance (m)	0.021	0.049

When performing a RT, the athlete does not need to prepare for take-off, but rather place their foot on the take-off board. Without the take-off, the task is simplified, reducing the perceptual demand on the athlete, as evidenced by a 40% and 4% reduction in the global and local VR of RTs, respectively, compared to LJ run-ups (Figure 1a, b). With a later onset of VR during the RT, the athletes' can accelerate without adjusting for the approaching board. The prolonged unconstrained sprint results in a faster, longer stride pattern at the late onset of VR in RTs (Figure 1c, d). The late onset of VR, therefore, forces a more drastic gait adjustment to negotiate the board (Lee et al., 1982), significantly reducing step length and velocity just prior to the take-off board (Figure 1c, d).

The current study has demonstrated that early VR is critical for increased LJ distance and that the RT does not accurately simulate the VR phase of a LJ run-up. The current aim of the RT is not to teach VR, but to hone the athletes' stride pattern to the point where they will 'hit the board' without visually regulated adjustment. Coaches often facilitate this strategy by placing checkmarks next to the runway to guide the athlete during each phase of the approach, further minimizing the athlete's need to visually regulate their own stride pattern. Furthermore, the parameters of a 'stereotyped' approach are often set when the athlete's form and the environmental conditions are optimal. Athletes with this type of run-up are often reluctant to compete in less favorable conditions (Boas, 1997) in order to avoid adjusting their highly practiced, but non-adaptable run-up.

Athletes and coaches must understand that locomotion towards a narrow target always necessitates some form of visually regulated step adjustment (Bradshaw & Sparrow, 2002). The challenge for LJ coaches is, therefore, to develop activities that promote and train VR at high velocities. Bradshaw and Sparrow (2002) reported that the number of targets and the distance between consecutive targets significantly influences VR in both novice performers and national-class female gymnasts. One strategy to increase VR during the RT is, therefore, to place additional 'strips' across the runway and ask the athletes' to negotiate each target without sacrificing approach velocity. To avoid stereotyping the motor program, the number and placement of these targets should be randomly assigned for each repetition. For most LJ athletes, competition is held outside where variable wind conditions can significantly alter an athletes' stride pattern. Practicing consecutive RT or LJ run-ups with and then against the prevailing wind during training, may force adjustment during the running approach, therefore, training VR. Finally, varying the approach distance of consecutive RTs will also force the athlete to consciously regulate their stride pattern in order to strike the take-off board.

CONCLUSION: The findings of the current study, when integrated with previous literature strongly suggest that early VR is paramount for successful LJ performance. Early VR allows the athlete time to make small adjustments to their stride pattern in order to accurately strike the take-off board, without sacrificing approach velocity. The current training tool of the RT does not adequately train the athlete's visual perception strategies. Strategies to increase VR during the RT include using different approach distances and placing additional targets across the runway.

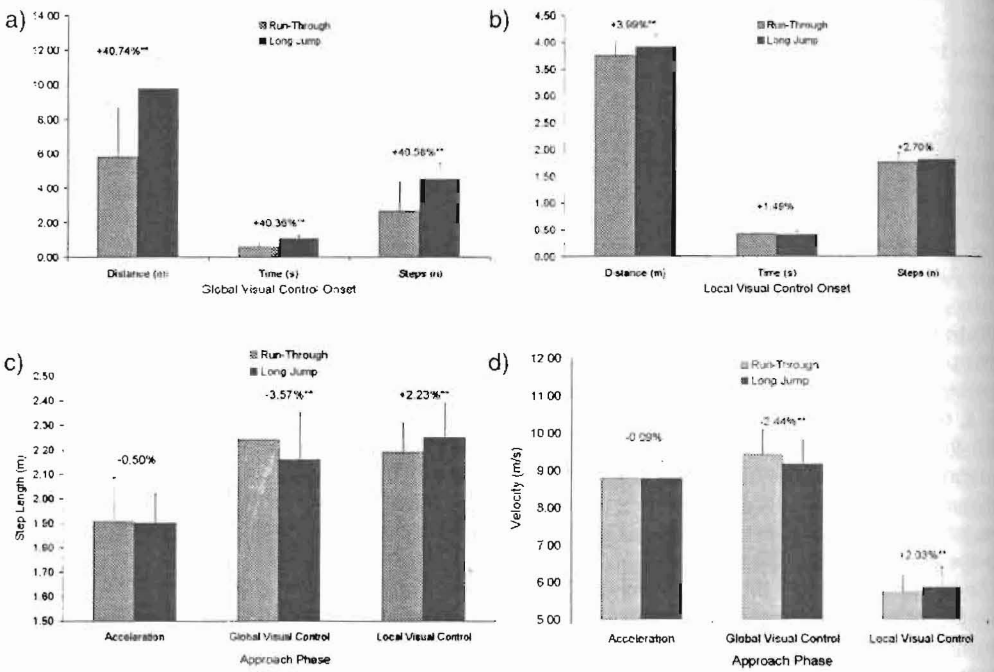

Figure 1: The mean approach characteristics of a RT and competition LJ as described by the velocity during the accelerative, global VR, and local VR phases (a), the spatial and temporal characteristics of VR (b), the spatial and temporal characteristics of the local VR component (c), and average step length during the three phases of the approach (d). ** Significantly different ($P < 0.01$) to RT.

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