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Evidence for Programmed and Visually Controlled Phases of the Triple Jump Approach Run

by Brian Maraj

ABSTRACT

The purpose of this experiment was to examine the approach run of the triple jump. Specifically the presence and absence of the takeoff board was manipulated in an attempt to identify the programmed and visual control phases of the approach run proposed in previous work. Participants performed run throughs and triple jump trials in the two visual conditions imposed by the board manipulation. For the conditions in which the takeoff board was present, the results indicated that there was a substantial decrease in variability of the footfall positions as the takeoff board was neared. However, for trials in which the takeoff board was not present, footfall position variability in the latter portion of the runup was much higher than for the early portion of the approach run.

Dr. Brian Maraj is Assistant Professor in the Faculty of Physical Education and Recreation at the University of Alberta in Edmonton, Canada. He coached athletes at university level in Canada from 1980-1991. He earned his Ph.D. from the University of Waterloo (Waterloo, Ontario, Canada) in 1995. Following the completion of his doctoral degree, he was employed in the Departments of Kinesiology at the University of Colorado (Boulder, Colorado) and at Louisiana State University (Baton Rouge, Louisiana) before assuming his current position. His area of teaching and research is in perceptual-motor behaviour.

In motor behaviour research, the approach run of horizontal jumps is an interesting and important skill to study. It provides an opportunity to examine the interaction of vision and locomotion which is an integral part of the long jump and the triple jump. By examining the approach run, researchers are afforded the opportunity to study the manner in which visual perception and the motor system are coordinated in skilled performance (Berg, et al, 1994; Hay, 1988; Hay, & Koh, 1988; Lee, et al., 1982; Maraj, et al. 1993; 1998).

Lee et al (1982) proposed that two distinct phases exist in the performance of the approach run of the long jump. Their investigation examined the manner in which long jumpers utilized visual information in the performance of their approach run in order to regulate their strides and arrive accurately on the takeoff board. In their study, three female long jumpers were filmed during two separate training sessions. The jumpers performed six jumps and six run throughs (i.e., full approach without actually taking off). The general question that the authors posed was: How is gait regulated to meet the demands of the approach run? Specifically, these researchers wanted to know the extent to which the runup (20-30 metres) to the takeoff board (20 cm wide) was stereotyped. That is, did the jumpers simply run off a preprogrammed motor command in the performance of the approach run? Supposing this was not the case, were the athletes using vision to regulate their gait and, if so, where in the approach was it most important?

Their results showed a decrease in footfall position variability over the few final strides. The authors broke the overall pattern of the approach into two parts. The first was a programmed phase in which the athletes tried to perform as stereotyped an approach as possible. During this phase, small inconsistencies in footfall position produced substantial accumulated error in foot position as the athlete neared the board. These inconsistencies were reflected in the increasing standard error of the footfall position that the athletes displayed for most of the approach run The proposition of two distinct phases of the approach run was also acknowledged by Hay (1988) in his study of 28 elite male and female long jumpers. Hay (1988), cited "serious limitations" (p.115) in the original work of Lee et al. (1982), and conducted two studies designed to replicate the Lee et al. findings. Film records were taken from a series of four major track and field meets. Toe-to-board distances (equivalent to Lee et al.'s footfall position) for each stride and the standard deviation of these distances were measured.

Hay's results showed a reduction in the variability in the toe-to-board distance (i.e., the standard deviation of the footfall position) as the jumpers approached the takeoff board. Hay concluded that the jumpers do indeed use a visual control strategy; a strategy which begins at the point of the maximum standard deviation of the footfall position. Hay's conclusion is based on the increasing trend in the standard deviation of the toe to board distance early in the runup followed by a decreasing trend for the final few strides. This supports the notion advanced by Lee et al. that the first part of the run up is programmed and the final few strides are under the control of vision as the jumper nears the board.

A more recent study (Berg et al., 1994) examined the film records of novice long jumpers in competition. Their purpose was to extend the work of Lee et al. (1982) to include novice long jumpers. Their results showed that the pattern of footfall variability in the approach run was very similar to the findings of Lee et al. The authors attributed the change in footfall position variability to the visual regulation of stride length as the jumpers approached the board. This work is important in that it not only replicated the findings of the Lee et al. study, but also extended the results to novice jumpers.

While the previous work was based on a descriptive level of footfall position data, our purpose in the experiment undertaken was to provide a quantitative assessment of the programmed and visually controlled phases of the approach run. Previous studies on the use of vision in this motor skill have suggested that the approach run is under visual control at the arbitrary point of maximum standard deviation of footfall position of the approach. The manner in which vision guides the jumper in this portion of the approach run is critical to the suggestion that there are two distinct phases in the approach run. The question in this investigation was posed with respect to the role that vision of the board plays in the entire duration of the approach. That is, can we more precisely discern the programmed phase and a visually controlled phase in the approach run?

In the following experiment, the intention was to employ a methodology that would allow us to more closely examine the notion that there are two distinct phases in the approach run of horizontal jumps. The triple jump is one of the horizontal jumps that has been studied from a mechanical perspective (Fukashiro, Iimoto, Kobayashi, & Miyashita,1981; Fukashiro & Miyashita, 1983; Maraj, Elliott, Lee, & Pollock, 1994; Miller, & Hay, 1986). We chose this jumping event given that it has been shown to possess the same footfall position characteristics across the approach run as demonstrated in previous studies on the long jump (Maraj, Allard, & Elliott, 1998).

Method

Participants

One female and two male university athletes who were jumpers of an intermediate ability level volunteered to participate in the study. The ability level of the jumpers should not have a bearing on the footfall pattern seen in the approach run since it has been demonstrated that even novice jumpers display the same footfall variability pattern as higher level jumpers (e.g., Berg et al., 1994; Maraj et al., 1998).

Task

Participants performed six (6) trials in each of four (4) different conditions:

i) Run through with no takeoff board
ii) Full approach and jump with no takeoff board
iii) Run through with the takeoff board
iv) Full approach and jump with the take off board

Each jumper performed a total of 24 trials (4 blocks of six trials) with short breaks between each jump and a longer interval between each condition. They were instructed to perform their approach run and to either jump or to run through. They were informed whether the takeoff board would or would not be present. The order of trials was 1) Run through with no board, 2) Jump with no board, 3) Run through with the board, 4) Jump with the board. The no board trials were conducted first so that positional recall of the board in subsequent trials would not be an influencing factor.

Apparatus

The runway was a hardwood surface 22 metres in length and, although shorter than that used by many higher level jumpers (which can be in the range of 30 - 40 metres), the dimensions were adequate for the level of jumpers in this experiment. For the trials with a takeoff board, a 20 cm by 1-metre board with a 10-cm foul area outlined at the uppermost end were constructed. The takeoff board was white in colour and very visible to the subjects. The foul area was black in colour and provided a definitive marker as to the end of the 20-cm legal jumping area for the takeoff board. The use of an indoor facility provided a constant climate and the environmental constancy not always found in outdoor competitions (i.e., wind, rain).

Data capture

Two video cameras (Panasonic 450AGF and PK-14-V) were set up perpendicular to the running surface to capture the approach run up. The cameras were spaced approximately 10 metres apart, elevated to a filming height of 1.5 metres, and were situated 20 metres away from the runway. The first camera captured the run up from the initial stride to 10 metres before the takeoff board. The second camera captured the subjects from that point to beyond the takeoff and into the hop phase. The camera speed was 60 frames per second for each unit. Markers were placed on the heel and toe of the subjects' shoes, and on their hip as reference points for digitizing. Objects of known lengths placed in view of each camera allowed for developing appropriate horizontal and vertical linear scales.

The film was digitized using the Peak Performance (2D) system. The foot position data was taken from the toe marker placed on the subjects' shoes. This was captured for each step cycle and yielded the raw data. All the data was stored and the appropriate conversion factor was utilized in order to transform the data for acquisition of the dependent measures. Test/re-test measures determined the degree of spatial measurement error to be 1.5 cm and a temporal error of 16.67 ms was inherent due to the camera speed of 60 Hz.

Data Analysis

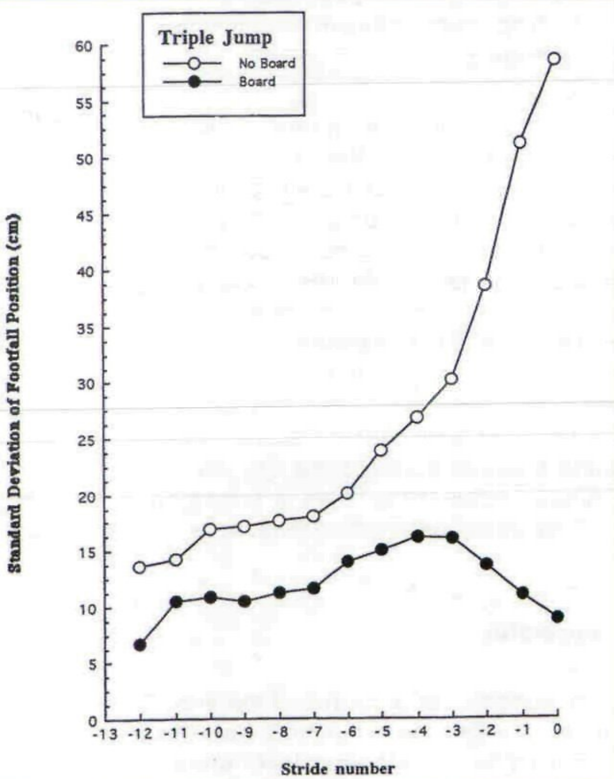
Repeated measures analyses of variance (ANOVA) were employed to examine the different condition manipulations. The chief measure of interest was the standard deviation of the footfall positions for the subjects across the six trials in each of the four conditions. The standard deviation of footfall position is a measure of the variability of the position of the foot landing on each stride. Footfall positions were measured with respect to the edge of the takeoff board and the standard deviation of foot positions of each stride across the 6 trials was calculated. In trials with no takeoff board, a predetermined point of reference close to the end of the runway was used and measures were taken back from this point to give the footfall position in these trials for each stride.

Results and Discussion

Previous studies on the horizontal jumps have divided the approach run into two phases. The first being a programmed phase in which the jumpers try to produce as stereotyped an approach as possible. The second phase is considered to be under visual control as the jumper uses the takeoff board to guide them to an accurate takeoff position on the board. The purpose of this experiment was to more clearly identify these two possible phases in the approach run.

Figure 1 shows the mean standard deviations for the triple jump in conditions with and without the takeoff board for all 3 subjects. With the takeoff board there is a systematic reduction in standard deviation towards the end of the approach run. The data obtained was very similar to that previously reported. However, the no board trial results show the same pattern for much of the approach run but deviate significantly in the final strides of the approach run. What can be gleaned from this graph is the point at which visual control comes into play for the subjects. On close observation, it appears that this point of visual control occurs at 3 - 4 strides before takeoff. This highlights not only the differences in the footfall position for the two conditions but can also aid in determining the point at which visual control of gait occurs in the approach run. Given the pattern described in the previous studies on the long jump, the triple jump data lends support to the notion first put forward by Lee et al. (1982), that the control of final strides of the approach run may be based on vision. The design of the present investigation allows the presence of these two phases to be tested statistically.

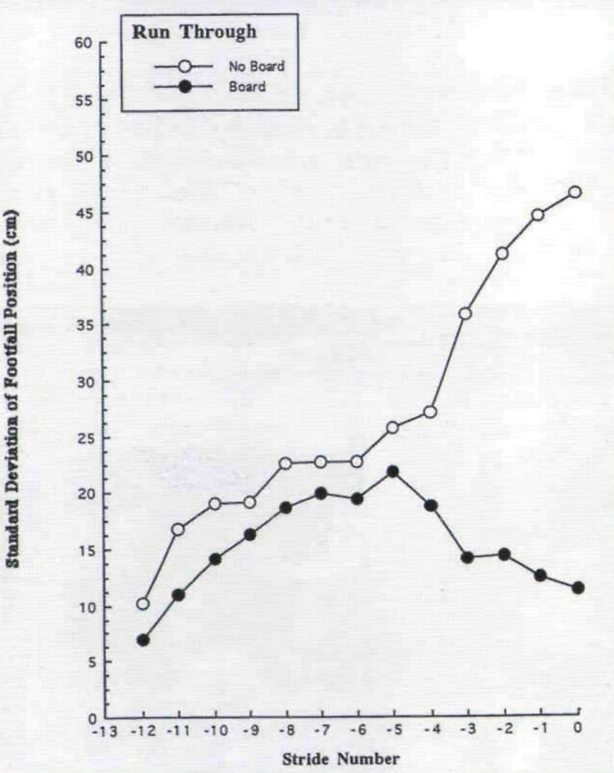
Figure 1. Footfall position variability over 13 strides in the triple jump condition with and without a takeoff board.



The data for the approach run in the triple jump condition with the board manipulation was analyzed using a 2 (Condition) by 13 (Strides) repeated measures analysis of variance. This allows a statistical evaluation of the change in the footfall variability that is evident towards the end of the approach run in Figure 1. In spite of the fact that we are dealing with 1 and 2 degrees of freedom, the results still revealed main effects for Condition $F(1, 2) = 213.0$, $p < .01$, and Stride $F(10, 20) = 4.7$, $p < .01$; as well as a significant Condition by Stride interaction $F(10, 20) = 4.8$, $p < .01$. Post-hoc analysis (Tukey's HSD, $p < .01$) revealed no significant differences between the same stride number in each condition until stride -2. In other words, footfall position variability in these two conditions was significantly different for the final two strides before takeoff. In addition to providing further evidence that the board is driving the decreased variability of footfall positions in the final strides before takeoff, these results support the final two strides as being the point at which visual control of the movement begins.

Figure 2 shows the pattern of footfall variability in the run through condition. The mean data for the participants shows the overall pattern that emerges is very similar to the jump conditions (Figure 1). The pattern of footfall variability for the jump and run through conditions of the triple jump appears to support the two phases of the approach run. The very robust pattern that was previously seen in the triple jump condition was very evident again. It is apparent that the approach run is stereotyped (or programmed) for a large portion of the approach duration and changes to a mode of visual control as the jumper nears the board.

Figure 2. Footfall position variability over 13 strides in the run through condition with and without a takeoff board.



The takeoff board plays a vital role in visually guiding jumpers in preparation of horizontal jump performance. This visual information does not influence the approach run until the final few strides. This highlights the fact that in the performance of motor skills, regulatory stimuli (such as the takeoff board) plays an important role in guiding behaviour (Gentile, 1972). Coaches should facilitate practice sessions that can enhance the athlete's performance and utilize the components of programmed and visually controlled phases in the approach run. The practical application of this work for coaches would be to place an emphasis on attaining a consistent pattern of striding to minimize errors in the programming portion of the approach run. While this is a part of the regime of many coaches in the horizontal jumps there is little attention given to the visual control portion of the approach run. In keeping with the data from this study and others (e.g., Hay & Koh, 1988), it is important to incorporate drills that address the visual control portion as well. Drills which will assist the athlete in perception of distance and in making accommodations (in stride length) to arrive at a given target position would be very helpful in addressing the visual control phase of the approach run.

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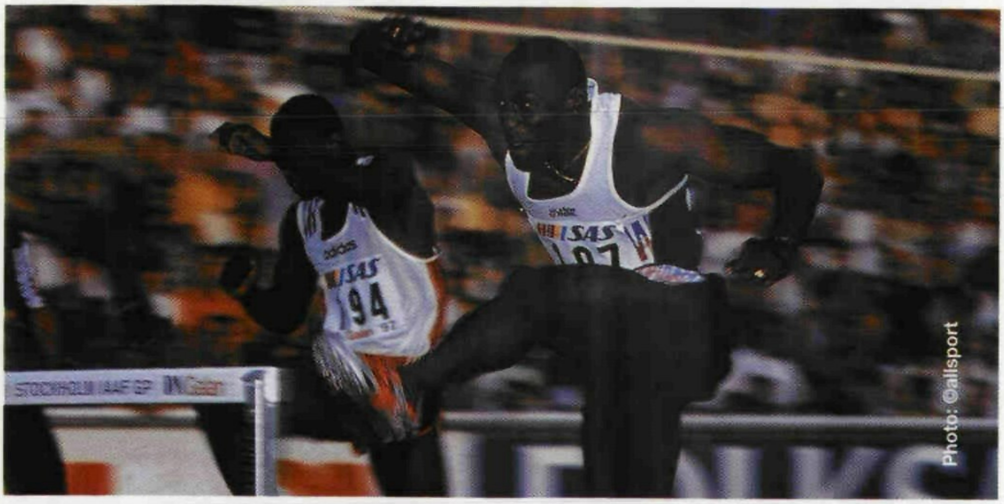

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