

## **STRIDE LENGTH REGULATION AT THE APPROACH PHASE OF LONG JUMP IN VISUALLY IMPAIRED (F12 CLASS) ATHLETES**

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The present study examined whether long jumpers with visual impairment (class F12) demonstrate at the approach run the same pattern of footfall variability across trials as athletes without visual impairment. Five male and five female elite F12 class long jumpers were recorded during a competition. The athletes demonstrated an initial ascending footfall variability followed by a descending one, suggesting the existence of stride length regulation. This regulation emerged on the fourth and the third stride prior to take-off area and at a mean distance of  $9.09 \pm 0.26$  m and  $6.28 \pm 0.26$  m for the males and the females respectively from the take-off line. Results indicated that the stride pattern of F12 class long jumpers was similar to that reported in the literature for athletes without visual impairment, with stride regulation commencing one stride closer to the take-off board.

**KEY WORDS:** visual control strategy, footfall variability, toe-to-board distance, accuracy requirement, panned video recording.

**INTRODUCTION:** Success in the long jump is decisively determined by the approach phase and the technical skill of placing the take-off foot on the board with accuracy, speed and proper mechanics. A proper approach run profoundly depends on the consistency of its distance, number of strides and pattern of speed development across all tries. Research conducted so far on the event (Lee et al., 1982; Hay, 1988; Hay and Koh, 1988; Berg and Greer, 1995; Scott et al., 1997; Bradshaw and Aisbett, 2006) suggests that performers, in order to achieve precise foot placement on the board, regulate the final 4-5 strides of the run-up using visual information which feeds a continuous control based on a perception-action coupling (Montagne et al., 2000).

All the theories described above stress the importance of vision in the regulation of the approach run in horizontal jumps. However, humans rely on other important sensory inputs as well. Berg and Mark (2005) proposed a multisensory tau hypothesis for step length adjustment in running, which takes into account the athletes' kinaesthetic perception while the target is localised visually. The question that arises is how long jumpers with visual impairment (VI) manage to fulfil the requirements for an accurate approach. The long jump for athletes with VI is one of the events of the International Blind Sport Association (IBSA) and Paralympics competition programme. Competing athletes are classified in three classes according to the level of visual impairment (F11, F12 & F13). The event for class F12 is performed according to the IAAF competition rules, with the exception that the take-off area consists of a rectangle 1.00m x 1.22m and competitors may also use a caller (usually the coach) to provide acoustic orientation during the approach run. Visual perception of a class F12 athlete ranges from being able to recognize the shape of his hand, up to visual acuity of 2/60 and visual field of less than 5 degrees. Theoretically, a class F12 long jumper can hardly recognize an object (e.g. take-off board) at a distance of 2 meters that an athlete with no visual impairment would be able to observe at 60 meters.

The assimilation between non-visually impaired and visually impaired long jumping served as motivation for the present study. Both competitors during their approach phase aim for an optimal foot placement on the board. For non-visually impaired athletes, the role of vision during the approach phase is apparent and evident in the literature. The hypothesis that the present study investigated was if a step length regulation is present during the approach run of long jump in class F12 visually impaired athletes.

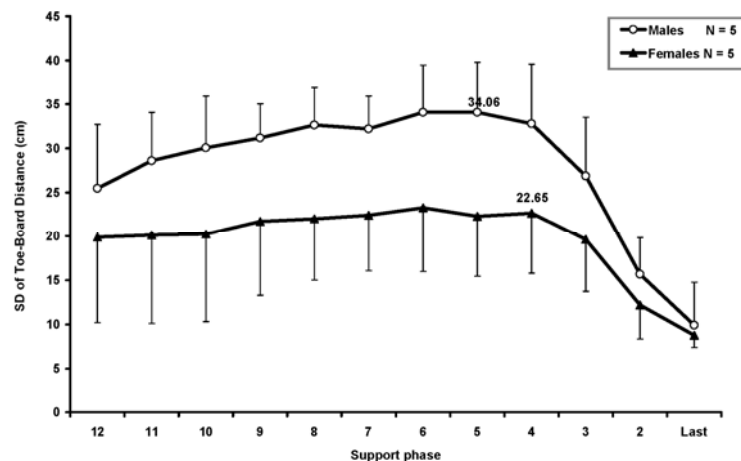
**METHODS:** The 5 finalists of the men's long jump and the 5 finalist of the women's long jump (class F12), of the International Blind Sport Association (IBSA) 2009 European Athletics Championship were recorded during the competition. The measurements took place during the long jump final of the 2009 European Athletics Championship. The set-up procedure took into account the instructions for the effectiveness of panning techniques for recording (Gervais et al., 1989). One-meter zones were marked on both sides of the runway to allow the measurement of the horizontal distance between the athletes' toe and the proximal to the pit edge of the take-off board (toe-board distance). All the approach runs were recorded with a digital video camera (SONY HDR-SR10, Sony, Minato, Tokyo, Japan) operating at 50 frames/sec. The camera was zoomed in on the athletes' feet and was manually panned to allow the subject's entire run-up to be recorded. The camera was placed at a distance of 15 m from the midline of the runway and 3m higher from the ground level allowing good visibility of all the markers on the runway. The procedures used for data collection did not interfere with athletes' participation at the event. All the participating athletes performed at least 5 legal trials (out of a total of 6 jumps) which were included in the analysis. In total, 59 legal run-ups were recorded for the 10 participants.

To calculate the toe-board distances for each support phase in every run-up of an athlete the five-point model described by Chow (1987) and cited in Hay and Koh, (1988) was used. Initially the toe-marker distance was designated by projecting the position of the toe onto a line between the two nearest markers on the ground. Toe-board distance (TBD) was then calculated by the addition of the toe-marker distance and the marker-board distance. The *mean* and the standard deviation (*SD*) of the toe-board-distance for each support phase of an athlete's foot on the ground across all his trials were calculated. The *SD* of the *mean* TBD reflected the variability in foot placement for a particular stride (Lee et al., 1982; Hay and Koh, 1988; Berg et al., 1994).

The validity of the procedure for calculating the TBD was assessed by recording a panning video with shoes placed on the runway at known distances (0.10m, 1.0m, 2.0m and thereon in two meter intervals from 3.0m up to 25.0m from the front edge of the take-off board). The TBD of the calibration shoe was then calculated using the same method as described above. The comparison between the actual shoe distance and the video recorded distance demonstrated an error of  $\pm 1\%$ . This amount of error was considered acceptable for the purposes of the study and compared favourably with previous investigations (e.g. Lee et al., 1982, 1cm; Hay and Koh, 1988, -1cm to +1.20cm; Scott et al., 1997, -1cm; Galloway and Connor 1999,  $\pm 2\%$ ). Furthermore, possible errors associated with panning recording were assessed with the use of a second stationary camera serving for a 2D-DLT analysis (Kollias, 1997). The camera (CASIO EX-FX1, Casio Computer Co. Ltd, Shibuya, Japan) operating at 300 frames/sec was positioned at a distance of 12 m with its optical axis perpendicular to the take-off board, and recorded the final four support phases of the athletes' approach run. The TBD calculated from the panning and the stationary camera, were then compared. The differences in TBD calculation between the 2D-DLT analysis were less than 0.5%, which again was considered acceptable for the purposes of the study. Therefore, only the data obtained with the panned camera were used for analysis which was conducted using the APAS 2010 software (Ariel Dynamics Inc., Trabuco Canyon, CA).

Descriptive statistics were used in order to calculate the *mean* and the *SD* of the TBD of each support phase across trials, as well as the *mean* and *SD* of the stride lengths. The intra-step analysis proposed by Montagne et al. (2000), was used in order to exploit any relationship (a parametric Pearson correlation coefficient was used) between the adjustment made and the adjustment needed at the last strides of the approach run (i.e. one stride before regulation appeared and thereafter). Statistical procedures were executed using the SPSS 10.0.1 software (SPSS, Chicago, IL). The level of statistical significance was set at  $p = .05$  for all analyses.

**RESULTS:** Male athletes demonstrated an initial ascending mean SD of TBD reaching a maximum value of  $0.341 \pm 0.057$ m on the 5<sup>th</sup> support phase (i.e. 4<sup>th</sup> stride from the board) and at a mean distance of  $9.09 \pm 0.260$  m from the take-off board. Similarly, female athletes as well reached a maximum TBD value of  $0.226 \pm 0.685$  m on the 4<sup>th</sup> support phase (i.e. 3<sup>rd</sup> stride from the board) and at a mean distance of  $6.28 \pm 0.260$  m from the take-off board. Following the point of TBD when maximum SD value was achieved, a descending trend was recorded for the remaining strides until the take-off board where the mean SD of TBD across trials was finally reduced to  $0.099 \pm 0.049$  m and  $0.088 \pm 0.014$  m for males and females respectively (Figure 1). The adjustment made and the adjustment needed (Montagne et al., 2000) were significantly related to each other, since correlation coefficients of .378 ( $p < 0.043$ ), .622 ( $p < 0.001$ ), .842 ( $p < 0.001$ ), and .782 ( $p < 0.001$ ) for males and of .542 ( $p < 0.002$ ), .642 ( $p < 0.002$ ), .815 ( $p < 0.001$ ), and 0.715 ( $p < 0.001$ ) for females were recorded for the 4<sup>th</sup>-last, 3<sup>rd</sup>-last, 2<sup>nd</sup>-last, and last stride respectively.



**Figure 1: Footfall variability across trials for male and female F12 class long jumpers' approach run.**

**DISCUSSION:** The objective of the present study was to investigate the pattern of footfall variability for F12 class elite male and female visually impaired long jumpers during the approach phase of the long jump during competition and to discuss the results compared to the existing data for non-visually impaired expert and novice long jumpers. Previous studies investigating the regulation of the stride length at the approach phase of the long jump suggested that the vast majority of the athletes, irrespective of their gender or level of expertise, display an ascending-descending trend of footfall variability over trials (Lee et al., 1982; Hay, 1988; Hay and Koh, 1988; Berg et al., 1994; Scott et al., 1997; Galloway and Connor, 1999; Montagne et al., 2000; Bradshaw and Aisbett, 2006). The same pattern was found for all the F12 class athletes examined in this study, confirming the existence of ascending-descending trend of footfall variability in visually impaired long jumpers (Theodorou et al., 2011), suggesting that a stride length regulation pattern is not different compared to non-VI athletes.

The maximum SD value for TBD recorded at the present study (0.36 m for males and 0.27 m for females) were similar to those reported in several studies (Lee et al., 1982; Galloway and Connor, 1999), larger than the values noted in elite athletes (Hay, 1988; Hay and Koh, 1988) and considerably smaller compared to novices (Scott et al., 1997) This comparison suggests that F12 class VI high level athletes demonstrate a level of consistency in their approach run analogous to elite level non-VI athletes. In addition, the appearance of the descending pattern of footfall variability in the present study was favourably compared to that reported for non-VI athletes (Hay, 1988; Berg and Greer, 1995; Bradshaw and Aisbett, 2005). Those studies reported that stride length regulation was initiated in average on the 4th or 5th stride from the take-off board and at a distance ranging from 7.48 m to 10.0 m from the take-off point. In the present study, the descending pattern commenced approximately on the 5th and 4th foot placement (4<sup>th</sup> and 3<sup>rd</sup> stride) prior to the take-off area and at a mean TBD of 9.09 m and 6.28 m for VI males and females respectively.

**CONCLUSION:** The comparison of the data from the current study with those reported from other studies suggested that F12 class male and female VI athletes demonstrated an almost identical pattern of footfall variability and a regulation similar to non-VI athletes during the long jump's approach run. A question is raised as to how VI athletes manage to regulate their stride pattern in a similar fashion referred to non-VI jumpers, taking under consideration the fact that visual information is limited to them. Probably a multisensory tau, as described by Berg and Mark (2005), along with a highly developed kinaesthesia, using somatosensory and vestibular information, allows them to perceive their position relative to the approaching target. The linear relationship recorded at the last four strides between the adjustment needed and the adjustment made may be interpreted as evidence of a perception-action coupling. However, the laws of control and the nature of the inputs used by the athletes exceeded the scope of the present study. Further research is required in order to develop a strong theoretical background to support future researchers examining VI athletes in general.

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