# Essential parameters in female triple jump technique

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## ABSTRACT

*The purpose of the present study was to examine the performance of female triple jumpers under competitive conditions. The jumps of the ten participants in the women's triple jump at the European Athletics Premium Meeting "Thessaloniki 2008" were recorded using two digital video cameras operating at 100 fields per second and a 2D-DLT kinematic analysis was used for the calculation of selected biomechanical parameters. The author's findings confirmed a strong correlation (r=.816, p<.01) between approach velocity and triple jump performance. They found that the average phase distribution for the athletes studied was 36.5%, 29.3% and 34.2% for the hop, the step and the jump respectively and that the horizontal take-off velocity of the body's centre of mass (BCM) decreased approximately 1m/sec in each support from the hop to the jump. The results showed that the female triple jumpers who jumped over 15m in the competition had: i) maintained most of their BCM's horizontal velocity and exhibited a better conversion of horizontal-to-vertical velocity during the transition from the hop to the step, ii) greater BCM vertical velocities at the take-offs of the hop and the step, and iii) shorter support times and lower support time to flight time ratios.*

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## Introduction

The women's triple jump is a relatively new event, officially recognised by the IAAF only in 1990. Although it has been documented that "the mean distance of the best eight finalists have not changed" in World Championships from 1993 to 2005[1], the results of the women's triple jump in major competitions held in the last ten years reveal a general improvement in performance (see Table 1). It is also evident that the number of female jumpers over 15m in major competitions has increased progressively.

Among the factors that contribute to performance in the triple jump are the a horizontal velocity of the body's centre of mass' (BCM) attained during the approach, the conversion of horizontal-to-vertical velocity during the supports and the harmonious relationship between the flight time and the support time among the phases of the jump[2,3,4]. Performance in the triple jump is strongly correlated with the BCM velocity (both horizontal and vertical) and BCM height at the take-offs for the hop, the step and the jump[5,6]. Since the hop and the jump exhibit a small variance in the distance of the triple

*Table 1: Results (m) of the women's triple jump finalists at the IAAF World Championships in Athletics (WCH) and Olympic Games (OG) in the past decade (1999-2008)**

| COMPETITION | Winner | Bronze | 8th | To Qualify | >15m |
|---|---|---|---|---|---|
| WCH 1999 | 14.88m | 14.61m | 14.38m | 14.20m | 0 |
| OG 2000 | 15.20m | 14.96m | 13.97m | 13.98m | 2 |
| WCH 2001 | 15.25m | 14.58m | 13.92m | 14.11m | 1 |
| WCH 2003 | 15.18m | 14.90m | 14.34m | 14.16m | 2 |
| OG 2004 | 15.30m | 15.14m | 14.79m | 14.52m | 4 |
| WCH 2005 | 15.11m | 14.78m | 14.31m | 14.11m | 1 |
| WCH 2007 | 15.28m | 15.04m | 14.50m | 14.20m | 3 |
| OG 2008 | 15.39m | 15.23m | 14.73m | 14.18m | 6 |

* *according to http://www.iaaf.org/history (downloaded: 13 Sept. 2008)*

jump[7], performance is dependent on the optimum execution of the step and particularly the transition between the hop and the step. The success of the execution of the transition from the hop to the step is defined by high velocity, wirde knee angle during the support and short contact time[8].

It has been noted that a lack of information exists in the literature concerning triple jumpers' velocity profiles and individual time managements, with respect to performance levels, techniques and gender[9]. The purpose of the present study was to examine the performance of female triple jumpers under competitive conditions in order to determine the reason for the athlete's ability to perform a leap over 15m and why a one athlete can leap over 15m while others have a poorer performance.

## Methods

### *Sample & Data Collection*

The subjects of this study were the ten participants in the women's triple jump at the European Athletics Premium Meeting "Thessaloniki 2008". All jumps were recorded using two stationary JVC GR-DVL 9600EG (Victor Co., Japan) digital video cameras operating at 100fields/sec. The cameras were positioned 15m from the left line of the runway at a height of 1.15m. The cameras were placed perpendicular to the plane of motion. The first camera recorded the last stride of the approach and the hop, while the other recorded the step and the support phase of the jump. The synchronisation of the video cameras was accomplished with the use of two simultaneously lit light emitting diodes (LED, frequency: 10Hz) in the view of each camera (Figure 1). For the execution of a 2D-DLT kinematic analysis[11], the runway and the take-off area were calibrated using a 2.5m x 2.5m frame with 16 control markers positioned perpendicular to the cameras' axis (Figure 2). The frame was placed consecutively along the centre line of the runway and the landing area. X-axis represented the direction of jumping along the runway. Y-axis was vertical and perpendicular to the x-axis.

### *Data Analysis*

All trials were recorded, but the best valid jump for each athlete was selected for further analysis. Twenty-two anatomical points of the body (tip of the toe, ankle, knee, hip, shoulder, elbow, wrist, fingers on both sides of the body and the head) were manually digitised in each field. The coordinates of the BCM were calculated for every field using a combination of segment parameters and anatomical data[12,13,14]. A 6Hz cut-off frequency was selected for smoothing based on residual analysis[15]. Digitisation, smoothing and analyses were conducted using the A.P.A.S.-System 2007 software (Ariel Dynamics Inc., Trabuco Canyon, CA). Descriptive statistics (average ± standard deviation) were utilised for the presentation of the results. Additional-

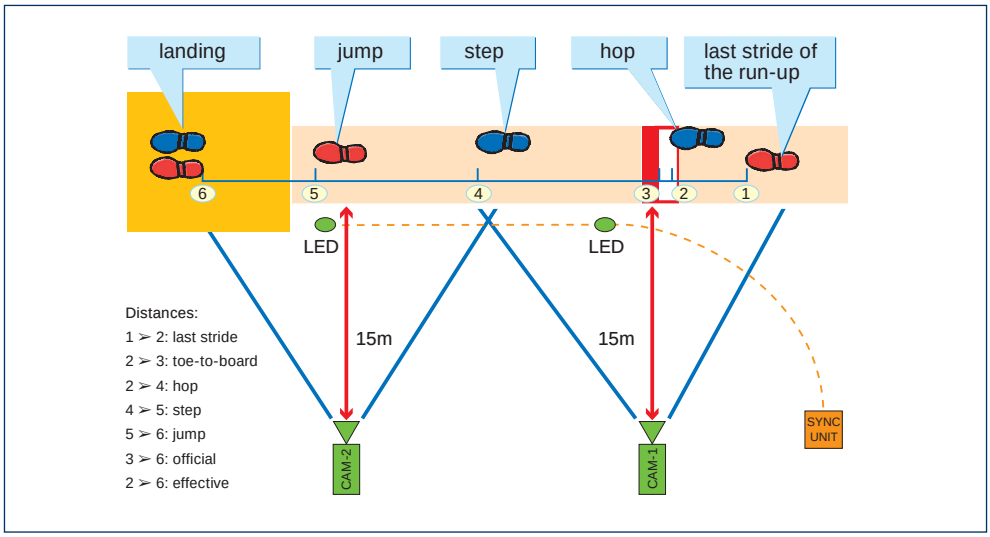


*Figure 1: The placement of the cameras, their filming views and the definitions of the distances examined (as defined by Brüggemann & Arampatzis[10])*

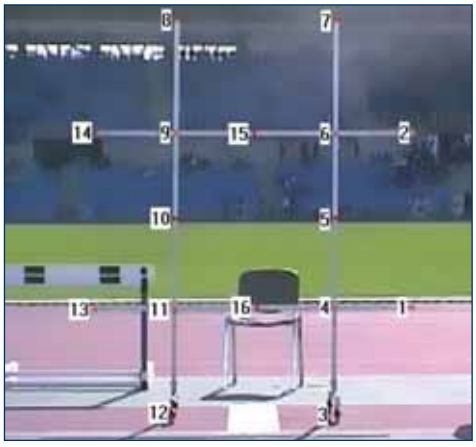


*Figure 2: The positioning of the calibration frame and its 16 control marks*

ly, a two-tailed Pearson correlation was used for the determination of the relationships among the examined biomechanical parameters with triple jump performance. All statistical procedures were conducted using the SPSS 10.0 software (SPSS Inc, Chicago, Il).

## Results & Discussion

The mean of the official results was 14.32m. Three athletes (Devetzi, Savigne and Sestak) jumped over or close to 15m (Table 2). The competition level was very high, since each of the first six athletes achieved more than 99% of their season bests. It is worth noticing that seven jumps were wind assisted (tail-wind velocity over 2m/sec).

The length of the last stride was approximately 2m, a value lower than findings from the World Championships in Athletics (2.24m)[1,10]. Kulyk was the only jumper to lower her BCM height during the last stride.

The jumpers who went over 15m achieved a BCM horizontal velocity of 8.7m/sec during the last stride, while jumpers of less than 13.5m achieved a BCM horizontal velocity of 7.9m/sec (Table 3). A strong correlation (r=.816, p<.01) between approach velocity and triple jump performance was revealed and this relationship is stronger than mentioned elsewhere (r=.791)[16]. This finding was in agreement with the fact that world class performances (jumps over 14.5m) are accomplished with an approach velocity of 8.7-8.9m/sec[9,16,17] and the jumps over 15m performed in the 1995 World Championships in Athletics were accomplished with a final approach velocity greater than 9.2m/sec[18].

*Table 2: Official (DOFF), effective (DEFF), and toe-to-board (DTTB) distances (W: wind velocity) for the analysed jumps*

| ATHLETE | Nationality | DOFF (m) | DTTB (m) | DEFF (m) | Trial (#) | W (m/sec) | SB* (m) |
|---|---|---|---|---|---|---|---|
| DEVETZI | GRE | 15.22 | 0.03 | 15.25 | 3 | 1.5 | 15.23 |
| SAVIGNE | CUB | 15.15 | 0.02 | 15.17 | 6 | 1.5 | 15.20 |
| SESTAK | SLO | 14.90 | 0.07 | 14.97 | 2 | 2.9 | 15.03 |
| SALADUHA | UKR | 14.74 | 0.04 | 14.78 | 3 | 2.4 | 14.84 |
| VELDAKOVA | SVK | 14.37 | 0.07 | 14.44 | 4 | 3.4 | 14.51 |
| de OLIVEIRA | BRA | 14.21 | 0.02 | 14.23 | 3 | 3.5 | 14.28 |
| KULYK | UKR | 14.00 | 0.11 | 14.11 | 1 | 3.2 | 14.24 |
| TOPIC | SRB | 13.87 | 0.27 | 14.14 | 6 | 4.5 | 14.49 |
| DIMITRAKI | GRE | 13.48 | 0.02 | 13.50 | 1 | 3.0 | 14.10 |
| PANETA | GRE | 13.29 | 0.23 | 13.52 | 3 | 2.0 | 14.02 |
| Mean (n=10) | | 14.32 | 0.09 | 14.41 | | 2.79 | 14.59 |
| SD | | 0.67 | 0.09 | 0.63 | | 1.0 | 0.45 |

**according to http://www.iaaf.org/statistics/toplists (downloaded: 22 Oct. 2008)*

*Table 3: Stride length (1LS) and body centre of mass height (H), horizontal (UX) and vertical (UZ) velocity at the take-off for the last stride of the approach*

| ATHLETE | 1LS (m) | H (m) | UX (m/sec) | UY (m/sec) |
|---|---|---|---|---|
| DEVETZI | 1.92 | 1.01 | 8.68 | 0.29 |
| SAVIGNE | 1.93 | 1.01 | 8.85 | 0.24 |
| SESTAK | 1.93 | 1.01 | 8.28 | 0.18 |
| SALADUHA | 2.06 | 1.01 | 8.31 | 0.09 |
| VELDAKOVA | 2.06 | 1.03 | 8.44 | 0.22 |
| de OLIVEIRA | 1.67 | 0.95 | 8.26 | 0.25 |
| KULYK | 1.92 | 0.93 | 8.52 | -0.09 |
| TOPIC | 2.22 | * | * | * |
| DIMITRAKI | 2.09 | 1.05 | 7.94 | 0.33 |
| PANETA | 1.98 | 0.94 | 7.91 | 0.17 |
| Mean (n=10) | 1.98 | 0.99 | 8.35 | 0.19 |
| SD | 0.15 | 0.04 | 0.31 | 0.13 |

** It was not possible to calculate the take off parameters for the last stride of Topic's analyzed attempt because of a random incident during the filming of the event.*

The accuracy of the approach was generally precise, since all but two jumpers had a toe-to-board distance less than 7cm. Kulyk and de Oliveira managed to have a positive BCM vertical velocity (i.e. upward movement) at the instant of the touchdown to the take-off board.

The mean phase distribution was 36.5%, 29.3% and 34.2% for the hop, the step and the jump respectively (Table 4). The observed phase distribution was similar to that observed in contemporary top competitions (i.e. 2005 World Championships in Athletics: 36.2%-29.4%-34.5%)[1]. Deventzi and Savigne

*Table 4: The absolute (m) and relative (%) phase distances*

| PHASE | HOP | | STEP | | JUMP | | TECHNIQUE |
|---|---|---|---|---|---|---|---|
| ATHLETE | m | % | m | % | m | % | |
| DEVETZI | 5.75 | 37.7 | 4.39 | 28.8 | 5.11 | 33.5 | Hop dominated |
| SAVIGNE | 5.71 | 37.6 | 4.26 | 28.1 | 5.20 | 34.3 | Hop dominated |
| SESTAK | 4.90 | 32.7 | 4.61 | 30.8 | 5.46 | 36.5 | Jump dominated |
| SALADUHA | 5.40 | 36.5 | 4.52 | 30.6 | 4.86 | 32.9 | Hop dominated |
| VELDAKOVA | 5.19 | 35.9 | 4.17 | 28.9 | 5.08 | 35.1 | Balanced |
| de OLIVEIRA | 5.38 | 37.8 | 3.92 | 27.5 | 4.93 | 34.7 | Hop dominated |
| KULYK | 5.49 | 38.9 | 4.12 | 29.2 | 4.50 | 31.9 | Hop dominated |
| TOPIC | 4.90 | 34.6 | 4.28 | 30.3 | 4.96 | 35.1 | Balanced |
| DIMITRAKI | 4.88 | 36.1 | 4.03 | 29.9 | 4.59 | 34.0 | Hop dominated |
| PANETA | 4.99 | 36.9 | 3.96 | 29.3 | 4.57 | 33.8 | Hop dominated |
| Mean (n=10) | 5.27 | 36.5 | 4.23 | 29.3 | 4.93 | 34.2 | |
| SD | 0.33 | 1.7 | 0.23 | 1.0 | 0.31 | 1.2 | |

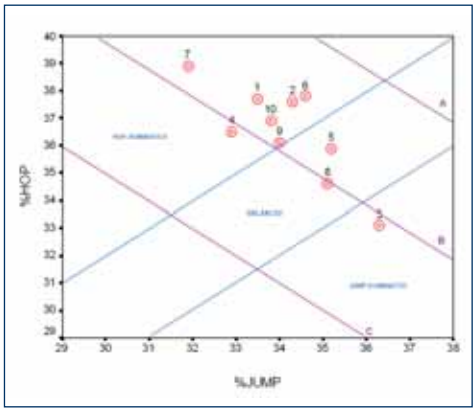


*Figure 3: Classification of the examined jumpers (the legend indicates the ranking of the athlete) based on the triple jump distribution (constructed according to Hay[19]) (Lines A, B and C indicate the step phase ratio of 25%, 30% and 35% respectively).*

had a hop percentage of about 37.5%. Equal and even larger hop percentages were observed for De Oliveira and Kulyk. Sestak performed the jump with the largest phase percentage (36.5%), with Kulyk exhibiting the lowest value for that phase.

The hop dominated technique was more common among the jumpers (Figure 3), as is generally reported for female triple jumpers[16,20]. However, jump dominated or balanced techniques are more frequently observed in elite level competition[1,10].

Mean BCM horizontal take-off velocity decreased approximately 1m/sec in each take-off from the hop to the jump (Table 5), as is noted in the literature[21]. The first two jumpers had values almost equal to the average value measured in recent World and European Championships[1,9,10]. The prevalence of hop-dominated techniques explains why both average BCM vertical take-off velocity and angle projection for the hop had larger values in the present study than in the above mentioned reports. On the contrary, the lower values in the same parameters recorded for the jump may be attributed to the lack of balanced and jump dominated techniques. This factor might also be responsible for the larger take-off angles for the hop and the step and the smaller take-off angle for the jump. It is worth mentioning that the vast majority of the examined jumpers had larger BCM vertical take-off velocity for the step than the mean values of the parameter recorded elsewhere[1,10]. The angle projection for the hop and the step were higher, while the angle projection for the jump was smaller than those reported in the

*Table 5: Horizontal ($U_X$) and vertical ($U_Y$) BCM take-off velocities and the angle of projection for the hop, the step and the jump*

| PHASE | HOP | | | STEP | | | JUMP | | |
|---|---|---|---|---|---|---|---|---|---|
| ATHLETE | $U_X$ (m/sec) | $U_Y$ (m/sec) | AngPr (deg) | $U_X$ (m/sec) | $U_Y$ (m/sec) | AngPr (deg) | $U_X$ (m/sec) | $U_Y$ (m/sec) | AngPr (deg) |
| DEVETZI | 8.30 | 2.79 | 18.6 | 7.64 | 1.93 | 14.2 | 6.80 | 2.39 | 19.4 |
| SAVIGNE | 8.67 | 2.51 | 16.1 | 7.62 | 1.65 | 12.2 | 6.22 | 2.32 | 20.5 |
| SESTAK | 8.10 | 2.46 | 16.9 | 7.20 | 1.61 | 12.6 | 6.03 | 2.49 | 22.4 |
| SALADUHA | 7.75 | 2.54 | 18.1 | 6.66 | 1.62 | 13.7 | 5.82 | 2.58 | 23.9 |
| VELDAKOVA | 8.31 | 2.29 | 15.4 | 7.32 | 1.81 | 13.9 | 6.21 | 2.14 | 19.0 |
| de OLIVEIRA | 8.13 | 2.38 | 16.3 | 7.32 | 1.71 | 13.1 | 6.29 | 2.02 | 17.8 |
| KULYK | 7.98 | 2.83 | 19.5 | 6.96 | 1.66 | 13.4 | 5.61 | 2.17 | 21.1 |
| TOPIC | 7.80 | 2.18 | 17.5 | 6.92 | 1.52 | 12.4 | 6.25 | 2.29 | 20.1 |
| DIMITRAKI | 7.58 | 2.27 | 16.7 | 6.62 | 1.42 | 12.1 | 5.51 | 2.49 | 24.3 |
| PANETA | 7.68 | 2.61 | 18.8 | 6.88 | 1.24 | 10.2 | 6.11 | 2.04 | 18.5 |
| Mean (n=10) | 8.03 | 2.49 | 17.4 | 7.11 | 1.62 | 12.8 | 6.09 | 2.29 | 20.7 |
| SD | 0.3 | 0.2 | 1.3 | 0.4 | 0.2 | 1.2 | 0.4 | 0.2 | 2.2 |

past[1,10,18,22]. The evolution of this parameter through the triple jump was in agreement with the pattern described by Kreyer[23], which was also noted in World Championships[1,10,18].

At the instant of the take-off for the jump, the athletes had lost 28.5±3.6% of the BCM horizontal velocity measured at the last stride of the approach. The larger amount of BCM horizontal velocity lost during the support phases was the one during the transition from the step to the jump (Table 6), where the velocity deficiency was doubled compared the previous two supports (hop and step). BCM horizontal velocity decreased 5.6±2.6%, 6.0±2.2% and 14.5± 3.0% within the support for the hop, the step and the jump respectively. With the exception of the decrement observed for the step, the loss of BCM horizontal velocity was within the range of percentages found in the literature[21].

As expected, the greater amount of change of BCM vertical velocity within the support phases was found for the step and the jump, with the later being a little larger. The landings from the previous phases (the hop and the step) were responsible for this finding. The values of the change were limited when compared to the range of values reported in the early days of the event[22].

Average support and flight times for the hop were within the range of those reported for male jumpers[21]. However, the average support and flight times for the step and the jump were lower (Table 7). Devetzi & Savigne, both over 15m, showed a lower support time to flight time ratio (39%:61% support to flight, respectively).

Average landing distances (horizontal distance from the BCM projection on the ground to the point of contact) was almost equal for the hop and the step and larger for the jump (Table 8). The same pattern was also noted for male jumpers[24]. Average horizontal foot velocity during contact was higher at the instant of touchdown for the hop and lower for the step. The average foot placement velocity was also lower than those found in the literature and its development throughout the jump was not according to the patterns observed elsewhere[24,25].

The vast majority of the jumpers used single arm techniques. The use of the double-

*Table 6: Changes ($\Delta$) of the horizontal ($U_X$) and vertical ($U_Y$) body centre of mass velocities during the support phases of the hop, the step and the jump*

| PHASE | HOP | | STEP | | JUMP | |
|---|---|---|---|---|---|---|
| ATHLETE | $\Delta U_X$ (m/sec) | $\Delta U_Y$ (m/sec) | $\Delta U_X$ (m/sec) | $\Delta U_Y$ (m/sec) | $\Delta U_X$ (m/sec) | $\Delta U_Y$ (m/sec) |
| DEVETZI | -0.54 | 2.91 | -0.14 | 4.12 | -0.74 | 4.09 |
| SAVIGNE | -0.12 | 2.66 | -0.53 | 3.81 | -1.16 | 3.62 |
| SESTAK | -0.22 | 2.61 | -0.50 | 3.30 | -1.27 | 3.65 |
| SALADUHA | -0.82 | 2.87 | -0.68 | 3.73 | -0.70 | 3.92 |
| VELDAKOVA | -0.37 | 2.48 | -0.32 | 3.60 | -1.03 | 3.49 |
| de OLIVEIRA | -0.30 | 2.34 | -0.53 | 3.53 | -1.11 | 3.13 |
| KULYK | -0.49 | 2.83 | -0.36 | 3.67 | -1.02 | 3.43 |
| TOPIC | -0.62 | 2.46 | -0.61 | 3.59 | -1.10 | 3.63 |
| DIMITRAKI | -0.67 | 2.87 | -0.32 | 2.98 | -1.35 | 3.81 |
| PANETA | -0.64 | 2.65 | -0.57 | 3.14 | -0.83 | 3.32 |
| Mean (n=10) | -0.48 | 2.67 | -0.46 | 3.55 | -1.03 | 3.61 |
| SD | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 |

*Table 7: Average contact and flight times (seconds) during the last approach stride and during the hop, step and jump (Total time refers to time from the touchdown for the hop until the take-off for the jump.)*

| PHASE | LAST | STRI | DE | HOP | STEP | JUMP | TOTAL | TIME | |
|---|---|---|---|---|---|---|---|---|---|
| ATHLETE | Support | Flight | Support | Flight | Support | Flight | Support | Support | Flight |
| DEVETZI | 0.09 | 0.09 | 0.11 | 0.58 | 0.14 | 0.42 | 0.14 | 0.39 | 1.00 |
| SAVIGNE | 0.10 | 0.12 | 0.10 | 0.54 | 0.12 | 0.41 | 0.15 | 0.37 | 0.95 |
| SESTAK | 0.12 | 0.11 | 0.10 | 0.51 | 0.13 | 0.38 | 0.14 | 0.37 | 0.89 |
| SALADUHA | 0.12 | 0.09 | 0.13 | 0.58 | 0.16 | 0.42 | 0.16 | 0.45 | 1.00 |
| VELDAKOVA | 0.10 | 0.12 | 0.12 | 0.50 | 0.14 | 0.36 | 0.15 | 0.41 | 0.86 |
| de OLIVEIRA | 0.09 | 0.10 | 0.10 | 0.52 | 0.13 | 0.37 | 0.13 | 0.36 | 0.89 |
| KULYK | 0.12 | 0.09 | 0.12 | 0.59 | 0.16 | 0.38 | 0.18 | 0.46 | 0.97 |
| TOPIC | * | * | 0.12 | 0.51 | 0.14 | 0.41 | 0.12 | 0.38 | 0.92 |
| DIMITRAKI | 0.11 | 0.11 | 0.13 | 0.52 | 0.15 | 0.33 | 0.17 | 0.45 | 0.85 |
| PANETA | 0.11 | 0.11 | 0.12 | 0.53 | 0.15 | 0.32 | 0.14 | 0.41 | 0.85 |
| Mean (n=10) | 0.11 | 0.10 | 0.12 | 0.54 | 0.14 | 0.38 | 0.15 | 0.41 | 0.92 |
| SD | 0.01 | 0.01 | 0.01 | 0.03 | 0.01 | 0.04 | 0.02 | 0.04 | 0.06 |

** It was not possible to calculate the contact and flight time for the last stride of Topic's analyzed attempt because of a random incident during the filming of the event.*

arm method is an indicator for power-oriented jumpers, whilst the use of the single-arm method is characteristic in speed-oriented jumpers[26]. However, a combination of single arm technique for the hop and double arm technique for the step has been suggested[2,27]. As for other aspects of the technique, the use of the criteria defined in the Model Technique Analysis Sheet proposed by HUTT[2] revealed that common failures were the inability to

*Table 8: Landing distance (STD) and linear ankle velocity ($Ua_X$) at the instant of touchdown for the hop, the step and the jump.*

| PHASE | HOP | | STEP | | JUMP | |
|---|---|---|---|---|---|---|
| ATHLETE | $S_{TD}$ (m) | $Ua_X$ (m/sec) | $S_{TD}$ (m) | $Ua_X$ (m/sec) | $S_{TD}$ (m) | $Ua_X$ (m/sec) |
| DEVETZI | 0.47 | 2.42 | 0.58 | 1.03 | 0.50 | 1.33 |
| SAVIGNE | 0.50 | 1.81 | 0.51 | 2.11 | 0.59 | 2.27 |
| SESTAK | 0.42 | 1.33 | 0.45 | 1.37 | 0.57 | 2.10 |
| SALADUHA | 0.61 | 2.06 | 0.58 | 1.52 | 0.51 | 1.28 |
| VELDAKOVA | 0.50 | 2.11 | 0.52 | 1.59 | 0.53 | 2.29 |
| de OLIVEIRA | 0.45 | 1.51 | 0.51 | 1.33 | 0.52 | 1.66 |
| KULYK | 0.54 | 2.20 | 0.56 | 1.60 | 0.60 | 1.88 |
| TOPIC | 0.53 | 1.86 | 0.54 | 1.26 | 0.58 | 1.19 |
| DIMITRAKI | 0.55 | 2.70 | 0.37 | 1.14 | 0.58 | 2.07 |
| PANETA | 0.39 | 1.71 | 0.46 | 0.94 | 0.51 | 1.52 |
| Mean (n=10) | 0.50 | 1.97 | 0.51 | 1.39 | 0.55 | 1.76 |
| SD | 0.07 | 0.41 | 0.07 | 0.34 | 0.04 | 0.42 |

raise the swinging leg up to the horizontal level at the take-off for the step (#17) and the jump (#27) and the positioning of the front leg during the flight phase of the step (#21).

## Conclusion

Results indicated that the female triple jumpers who jumped over 15m had:

1. maintained most of their BCM horizontal velocity during the transition from the hop to the step;
2. better conversion of horizontal-to-vertical velocity during the transition from the hop to the step;
3. larger BCM vertical velocities at the take-offs of the hop and the step;
4. shorter support times and lower support/flight time ratios.

Among the factors for effective triple jump performance is the determination of the optimum phase distance ratio[21]. It has been suggested that female triple jumpers function more efficiently by using the step as a transitional period in order to place the greatest amount of emphasis on the hop and jump phases[16]. Conversely, a reduction in hop percentage leads to an increase in both the jump percentage and the actual distance[28]. However, the hop was the longest phase for the examined athletes over 15m.

In conclusion, more research is required to determine if a high approach velocity, paired with short contact times and with a more balanced jump technique or a lower peak approach velocity, combined with a lower jump-height and a balanced jump technique, leads to greater overall distances[20]. It remains to be seen if female athletes will reach 16m by the year 2015[29].

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